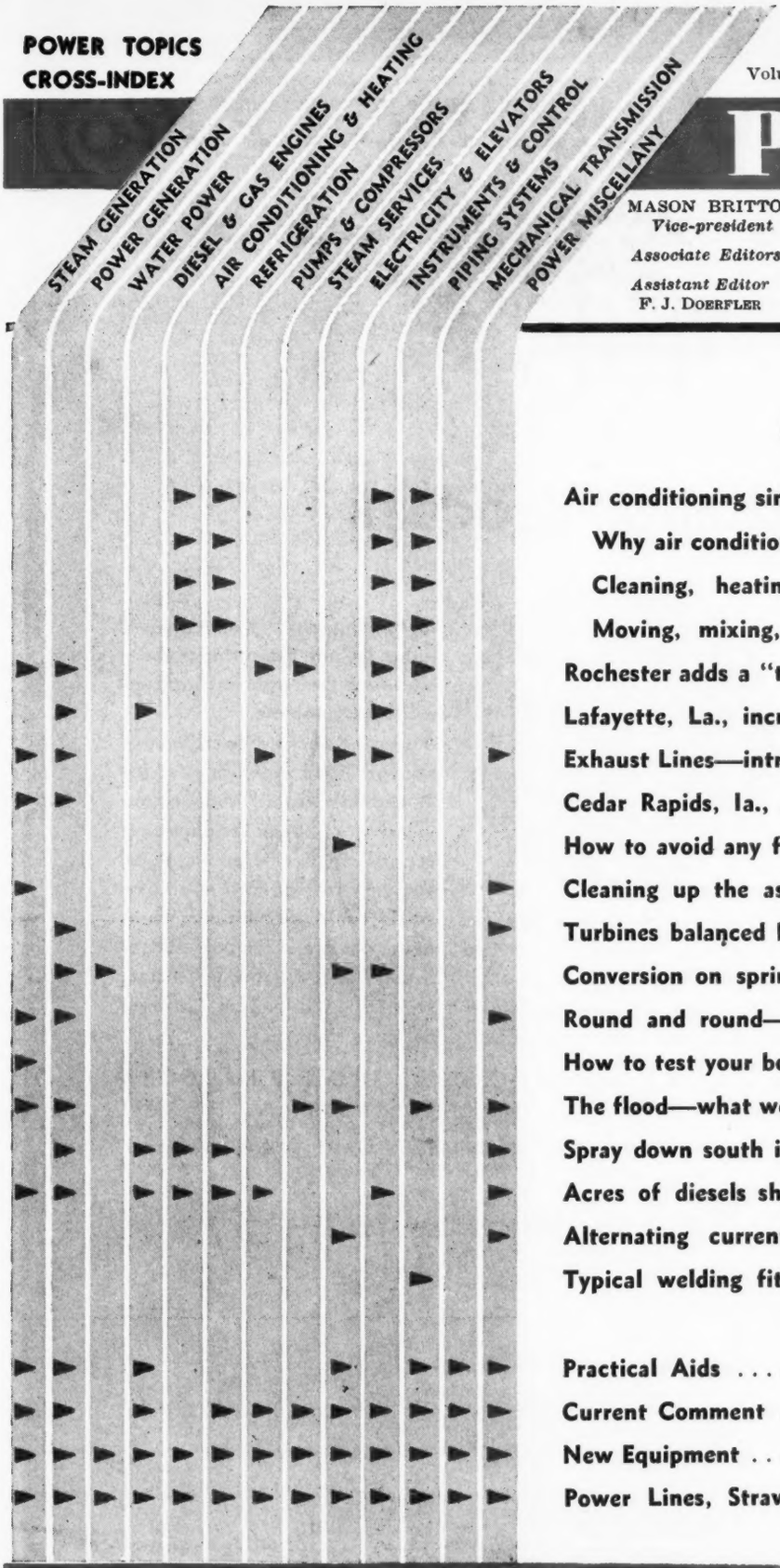

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POWER

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APRIL, 1936

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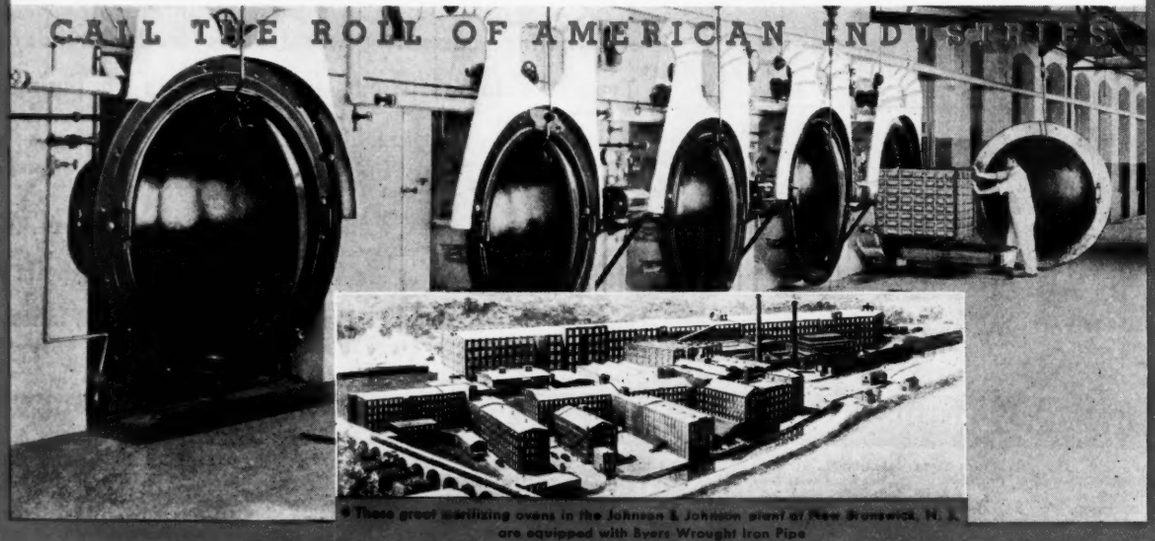

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POWER

A McGraw-Hill Publication—Established 1884
PHILIP W. SWAIN, *Editor*

AIR-CONDITIONED ENGINEERS

WHEN THE U.S., in 1917, faced the practical problems of building up a great national war machine in a matter of months, it did not start from zero. Thousands of organizations and millions of men who had never thought of military training or services had, in fact, been drilling in military fundamentals all their working lives.

Years before the War, young lumbermen up in the State of Washington were swinging axes, acquiring skill for later ax-swinging in the A.E.F. Wyoming cowboys riding their ponies were learning the hardest lessons of the cavalry and the horse-drawn light artillery. Automobile mechanics in Detroit and in garages all over the country were preparing themselves for service in a motorized army, as were numberless John Smiths driving and tinkering with the family car.

The math shark with a yachting hobby was learning the sextant and the course plotting and seamanship he would apply one day on the deck of a rolling destroyer; the boss on a road gang was training for the job of a line sergeant, but didnt know it. "Hams" tinkering with radios were lining up human Signal Corps material for Uncle Sam.

Because modern warfare is merely the redirection of the normal activities of a modern mechanized society and of those older every-day arts of cooking, eating, riding, chopping trees, riding and shooting squirrels, America was prepared to produce more war equipment and personnel in two years than she could have done in fifty if she had nothing to work with but peasants and a peasant civilization.

Reduced to a smaller scale, this snapshot of 1917 is almost a picture of air conditioning as the problem to be faced today by every power engineer in industry, institutions and public buildings.

America has declared war on atmospheric discomfort. Numerous volunteers have come forward to build, install and operate air-conditioning systems and the day of the universal draft is at hand. This year thousands of power engineers will find themselves "elected" to advise on the selection of air-conditioning systems to go into their own plants and then to take full responsibility for their operation. Next year it will be thousands more. Before long practically all power operators will be in this net, just as practically all now have building heating as a basic power-service responsibility.

Fortunately, the competent power engineer has been in training for this job a long time, even if he never gives "air conditioning" more than a passing thought. For air conditioning, like the military art, is largely compounded of everyday things, at least things that are everyday matters to the power engineer. It is nothing more than a canny combination of ventilation, refrigeration, heating, control, air-moistening, air drying, air cleaning. In the first four of these specialties the power engineer is already an old timer. For the last three he has already laid 50% of his technical groundwork.

The editors of *Power* have surveyed this present air-conditioning situation with particular reference to the human elements involved, notably the needs and backgrouund of their readers. They have decided that there is an editorial job to be done—an important and immediate service to be rendered to practical power men. That job is to take the mystery out of air conditioning, to reveal its few secrets and (more important) reveal where there aren't any secrets as far as *Power* readers are concerned. Hence this 20-page section on the elements of practical air conditioning.

In the pages that follow there will be no attempt to impress anybody with a mass of technical knowledge. In particular there will be no attempt to impress or educate air-conditioning "experts." They can, and will, take care of themselves. This section is designed to tell in plain powerplant English just what all the parading is about in this great war on uncomfortable air, to list for power engineers the essentials of the job of the air-conditioning line officer, to fill out three quarters of this specification with information he already has, and to give him the substance of the remaining 25%.

Fear, it has been remarked, is the greatest enemy of mankind. Don't fear air conditioning. It is easy, and far safer, to master this new combination of old elements of the power engineer's job.

ROAD MAP

THE first step in preparing for any journey is to study the road map, get your bearings, see what principal spots are to be visited and what general course is to be followed. Check-ups on hotels, filling stations and side trips can be made later.

And that is the way for any power engineer to start his study of air conditioning. Hence this simple "road map," showing all the primary, essential steps in air conditioning, and leaving out the confusing details.

To change the figure, this chart is the "Christmas tree" of air conditioning, upon which decorations and gadgets can later be hung in endless profusion. The first step is to know what the tree is supposed to look like. We therefore suggest that the reader study this simple chart until he has it practically memorized. Then he will have a framework upon which to hang information.

Mechanics have an old saying "A place for everything and everything in its place." That applies 100% to the study of air conditioning. If the right mental shelving can be set up at the start it will be a simple matter to pigeonhole for quick reference all one knows and will learn of the subject.

To turn back from Christmas trees and pigeon holes to the original idea of a road map, the experienced power engineer who studies the chart on this spread will be relieved to discover that there is "nothing to it." Practically the whole country to be covered in his journey is already familiar territory. He knows how to produce steam or hot water for heat and how to apply it to air-heating coils. He knows how to produce refrigeration and has some idea, at least, of how to use refrigerant or cold water in coils to cool air. He knows that cold tubes will sweat in moist air, nothing but the subtraction of water. He knows air will pick up moisture (if not saturated) when passed through spray warmer than its wet-bulb temperature. He may not have observed cases where a cold-water spray or film actually took water out of air, but he can understand the possibility, because the cold water will cool the air, and cold air at a given temperature can hold only so much water.

The fans used to blow air through coils and ducts will be an old story to him, as will most of the instruments and controls, with the possible exception of those related to humidity. As to air cleaning, he will have a general idea of how it may be accomplished by passing the air through fibrous masses, over surfaces covered with sticky fluids, over wet corrugated surfaces, or through a water spray. However, he will feel the need for getting more specific information about air cleaning.

Aside from the lack of experience in actually handling a complete air-conditioning system (as distinguished from its elements, with which he is largely familiar already) he will discover two educational needs. One is a clearer understanding of the amount of heat that moves in or out when a given quantity of moist air is heated or cooled over a given range. The other is the ability to reduce somewhat vague ideas about humidity to clear definitions and plain figures. This will take a little study, but not enough to be a burden. Pages 181, 182 and 186 give the practical essence of the subject.

When dealing later with the air-conditioning expert, don't worry if he makes the subject seem complex once more. Any subject from gold-headed canes to baseball can be made complex by the specialist, even though the important principles are few and not too difficult. A bit of advice here to the power engineer is to learn your own fundamentals; be sure you're right, and then bring the expert down to earth by asking him if this or that abstruse statement doesn't mean so and so in plain English.

The road map itself needs little explanation, but a few points should be made here. One relates to cleaning. When a filter is used, cleaning is always a separate operation, as shown. If, however, a spray is used for heating, cooling, humidifying or dehumidifying, it is obvious that this will also serve as an air cleaner.

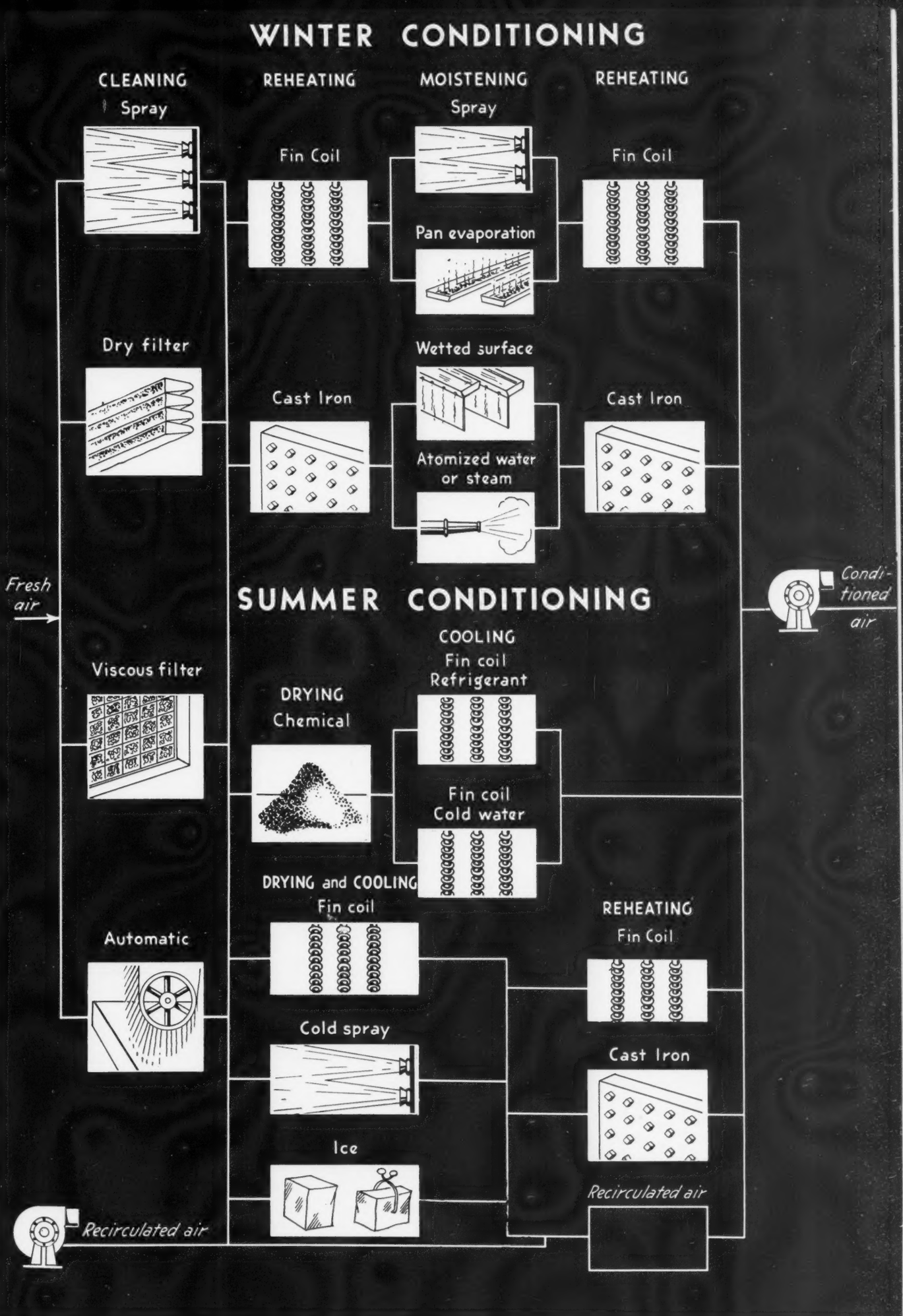
Here's another point: The map shows entirely distinct equipment for summer and winter. In practice, of course, the same equipment may be used. The spray that humidifies in winter may dehumidify in summer. The same fans serve in both summer and winter.

No attempt is made on this map to show how the required heat or cold is produced in the first place. That would merely confuse the main object. Moreover, the production of steam is so thoroughly understood by *Power* readers that it requires no comment in any part of this section.

With refrigeration it is different, although most readers are familiar with one or two refrigerating systems. In air conditioning, one must be prepared to choose intelligently among quite a few systems and will lose money and court trouble if he picks the wrong one for his particular conditions. Pages 191 and 192 will give the main characteristics of the different systems.

WHAT UNITS YOU NEED

TO	USE	REMARKS
CLEAN	FILTERS or WATER SPRAY	Dry, viscous, labyrinth May also be used to add or subtract water. Sprays also involve heaters, coolers, pumps
HEAT	COILS	Steam or hot-water supply
COOL	COILS or WATER SPRAY	Brine or refrigerant or refrigerated water or naturally cold water
	or ICE	Refrigerated or naturally cold or evaporation of the recirculated water
MOISTEN	SPRAYS or ATOMIZER or STEAM	Water temp. controls humidity
	or SURFACE EVAP.	From pans, wicks or trickle surfaces
DRY	COILS or SPRAYS	Cold enough to lower air below dewpoint. Brine or refrigerant or cooled or naturally cold water As above, except not refrigerated
	or CHEMICAL	Silica gel, calcium chloride or others which absorb water
DELIVER	FANS	Through equipment and to rooms


WINTER CONDITIONING
CLEANING
Spray
REHEATING
Fin Coil
MOISTENING
Spray
Pan evaporation
REHEATING
Fin Coil
Dry filter
Wetted surface
Cast Iron
Cast Iron
Atomized water or steam
Fresh air
Condi-tioned air
SUMMER CONDITIONING
Viscous filter
COOLING
Fin coil
Refrigerant
DRYING
Chemical
Fin coil
Cold water
DRYING and COOLING
Fin coil
REHEATING
Fin Coil
Automatic
Cold spray
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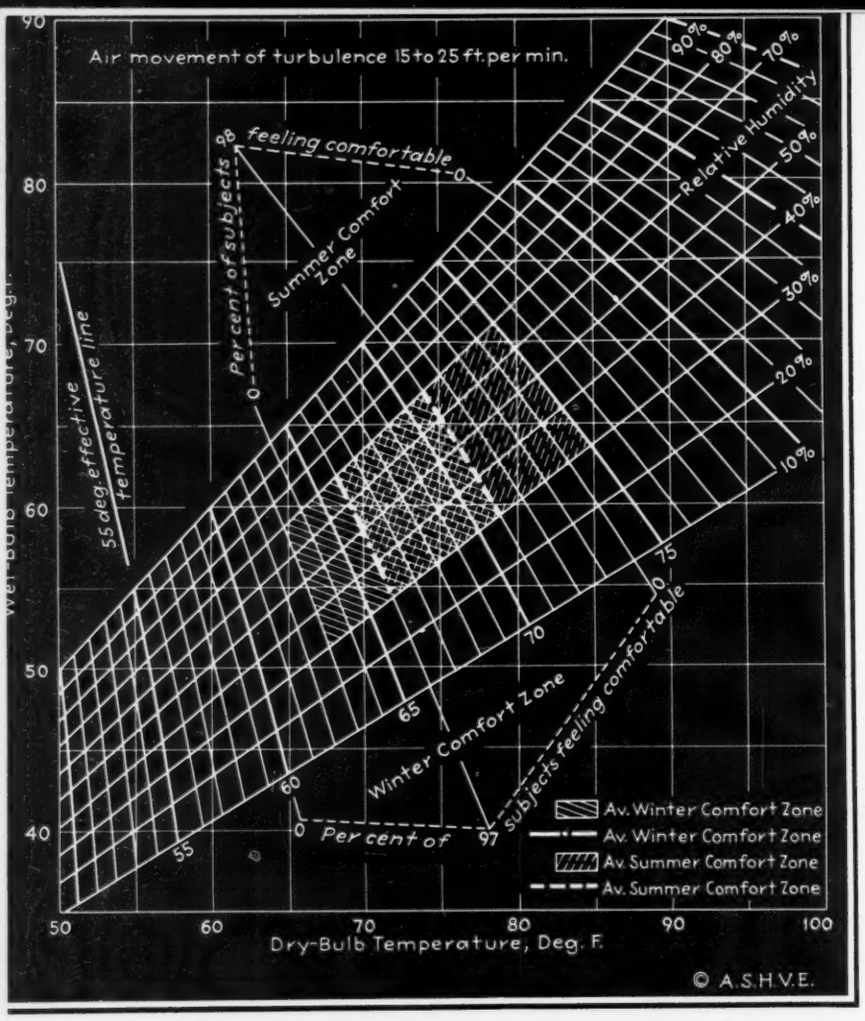
Recirculated air



WHY AIR CONDITIONING?

IT MAY be for comfort, to increase working efficiency, to better an industrial process. Depending upon use, the requirements change, but the basic answer to the question "why air conditioning?" is always the same—because it saves more than it costs.

As indicated in the "Road Map," there are six things conditioning may be expected to do to air; move it, clean it, heat it, cool it, moisten it, and dry it. Moistening and drying will not be required simultaneously, although cooling and heating may, for reasons discussed in the next article. Thus complete air conditioning involves five operations. But complete conditioning is only required for comfort, and air conditioning may have been installed for improvement of a process.

Industrial plants require widely varying temperatures and humidities, but the other factors are usually not so important. The bread you eat should be baked in a building at 80 to 90 deg. temperature and 80 to 95% relative humidity, but the electrical insulation you buy should be wound at 104 deg. temperature and only 5% relative humidity. Breweries want 50% R.H. and 44 to 55 deg. in their fermentation rooms, but food-storage rooms usually want 30 to 40 deg. and 80% R.H. They should process your "smokes" at 93 deg. and 85% R.H., but for making surgical rubber articles, 75 to 83 deg. at 25 to 30% R. H. is better.

Thus it goes. High relative humidity is the rule when it is desirable to keep water from evaporating from a product (i.e., food, tobacco), and low relative humidity where hygroscopic products (those that pick up atmospheric moisture, and shouldn't, such as insulation) have to be kept dry. There are also strictly drying processes.

In public places, though, air conditioning is the newest way to get more business. Theaters, hotels, offices, restaurants, stores, etc., are conditioning to make customers feel comfortable, therefore they have to know what constitutes comfort. People usually feel quite comfortable in summer temperatures of 75 deg., unless relative humidity gets up around the 90 mark. Then we complain about the heat. As some backwoods philosopher said, "It ain't the heat; it's the humidity" that is causing the trouble. Keep humidity down, and temperatures can go even higher without causing discomfort. Thus we know that comfort depends upon a *combination* of humidity and temperature. What then are proper limits?

The best available index is *effective temperature*, developed in the A.S.H.V.E. Research Laboratory (See *Transactions of the A.S.H.V.E.*, Vols. 27-34). This index isn't a true temperature of the air, but a synthetic index that combines temperature, humidity and air motion in a single value. It shows what particular combinations of the three things will make us *feel* the same. For example, the chart shows that we feel the same in air at 75 deg. and 60% R.H. as we do in air at 78 deg. and 30% R.H. In either case the effective temperature is 71 deg., just about Bermuda in any man's language.

This particular chart, which shows the relation of effective temperature to wet-bulb and dry-bulb temperature and relative humidity, is for air velocities up to about 25 f.p.m., which for all practical purposes is still air. If the air in the conditioned space is moving faster than the chart limits, you will have to boost temperature a few degrees to get the same effective temperature. For example, if the air movement gets up to 100 f.p.m., the effect on the chart is to move the effective-temperature line to the right, so that the line of 70-deg. effective temperature, as an example, intersects the saturation line at 72 deg. instead of 70.

We humans are funny people. We may feel cold when it isn't, and feel warm when other people are chilly, depending on what we're used to and on our particular constitutions. Not much can be done for the red-blooded individual who likes it a little chilly, or the hot-house flower who wants it a little over-warm, because conditioning must be based on the feelings of the average man. It is possible, however, and indeed necessary, to summer-condition in the South somewhat warmer than in the North, for Southerners are used to warmer weather, thus prefer higher effective temperatures. Another factor is the conditioned space itself. If three of its walls are exposed, thus cold in winter, the effective temperature will have to be higher to give the same feeling of comfort as that obtained in a space whose walls are at its temperature.

Furthermore, just because 71 deg. is considered the probable best effective temperature, don't assume that conditions should be maintained at that level always. If you were to enter a room at 71 deg. effective temperature from a warm outside day at 90 deg., you would suddenly feel quite chilly, and when you went back into the 90-deg outdoor air, you would feel over-warm. To avoid shocks caused by such sudden temperature changes, indoor effective temperatures must be increased as outdoor temperatures increase. For example, when it is 95 deg. outside (dry-bulb), the indoor dry-bulb should be 80 deg. with an effective temperature of 73. Humidity should be 40 to 50%.

Now, if you're an average person, where will you feel comfortable? The chart shows the limits. Average people feel comfortable at 30 to 70% R.H. (40 to 50 is best) at 66 to 75 deg. in summer. In winter, the comfort zone is 63 to 71 deg. effective temperature, but humidity is lower, because any high humidity would cause condensation on windows all the time. But that's another story, to be discussed in "Moistening," page 186.

STRAIGHT THINKING ON

HUMIDITY

NO MONUMENT will ever be erected to the first man who said "it ain't the heat; it's the humidity.". It is best so. Yet popular recognition of the fact that 70-deg. air is not necessarily comfortable has had a lot to do with the wide demand for air conditioning. And another factor in this demand is the realization by most Americans that zero outdoor air heated to 70 is too dry for healthy breathing. Humidity is a key factor in air conditioning and its understanding is basic to any understanding of the selection, control and operation of equipment.

At the possible risk of offending some by being too elementary, we propose in this article to reduce the whole subject of humidity to its ABC's.

Humidity, of course, refers to the weight of moisture associated with a pound of dry air. The common idea is that dry air acts something like a blotter or a sponge. It will "sponge" water off of a wet towel. While the air does act as a sponge as far as the towel is concerned, this sponge school of thinking is apt to cause trouble if applied to air conditioning.

At a given temperature, air may have varying amounts of water associated with it up to a certain maximum. To provide a measure of this the term relative humidity is used and is the ratio of the actual weight of water associated with a cubic foot of mixture to the maximum weight that can be associated with the air at the same temperature. One batch of air at 50% relative humidity may actually contain more water than another batch at 100%. High relative humidity is one thing, and a lot of water in the air is another.

The power engineer who studies air conditioning will get along faster if he forgets about the sponge and thinks only in terms of dry air and steam, mixed, and remembers that the steam is generally superheated.

Some call it water vapor, instead of steam, but there is no difference whatever; merely two names for the same thing. It is a little hard to imagine the ordinary atmosphere at 70 deg. F. being a simple mixture of dry air at 70 deg. and superheated steam at 70 deg., but that's what it is. To show that steam can be superheated at 70 deg., here are a few figures from the steam tables showing temperature, corresponding pressure and density of saturated steam:

Temperature, Deg. F.	Corresponding absolute pressure of saturated steam, in. of mercury	Weight, lb. per cu.ft.
40	0.258	0.0004
50	0.36	0.0006
60	0.52	0.0008
70	0.74	0.0011
80	1.03	0.0016
90	1.42	0.0021
100	1.93	0.0029

If you have a mixture of air and steam at 70 deg. and the pressure of the steam is 0.25 in. of mercury, you can see from this table that the steam is superheated 30 deg. (the difference between 40 and 70).

At this point the objection may be raised that the steam present can't have a pressure of merely 0.25 in., because the whole mixture is at atmospheric pressure (call it 30 in.), and every part of the mixture must have the same pressure.

Many years ago, however, the physicist Dalton demonstrated that each gas or vapor in a mixture at a given temperature contributes to the observed pressure the same amount that it would have exerted by itself at the same temperature had no other gas or vapor been present.

That is, always proceed on the assumption that a cubic foot of moist air at 30-in. pressure is a mixture of a cubic foot of dry air and a cubic foot of steam, that each has the temperature of the mixture and that the "partial pressure" of the air and the "partial pressure" of the steam add up to 30 in. of mercury if that happens to be the barometric pressure.

Look at the table again and imagine that you have a cubic foot of moist air at 70 deg. and that it contains 0.0011 lb. of water. The pressure of this vapor will be 0.74 in., so the air pressure must make up the difference of 29.26 in. to give the total pressure of 30 in. If you know the pressure and temperature of a cubic foot of air you can figure its weight by formula or table (not given). In this case the air weight figures 0.0720 lb. for one cubic foot, and a cubic foot of the mixture weighs 0.0731 lb.

This is given to show the principle involved. In practice you won't need to use the steam tables at all, because all combinations of water and air have already been figured out and the results put in convenient tables and diagrams.

In the case just presented, the steam was saturated; the mixture could soak up no more water. If less than 0.0011 lb. of steam had been present, say 0.0004 lb., the steam would have been superheated and more water could have been picked up. If a cubic foot of moist air contains only 0.0004 lb. of water when it could hold 0.0011 lb., its "relative humidity" is 4:11 or 36%. Now cool this mixture containing 0.0004 lb. or water to 40 deg. It won't lose or gain a bit of water, but its relative humidity will rise to 100%.

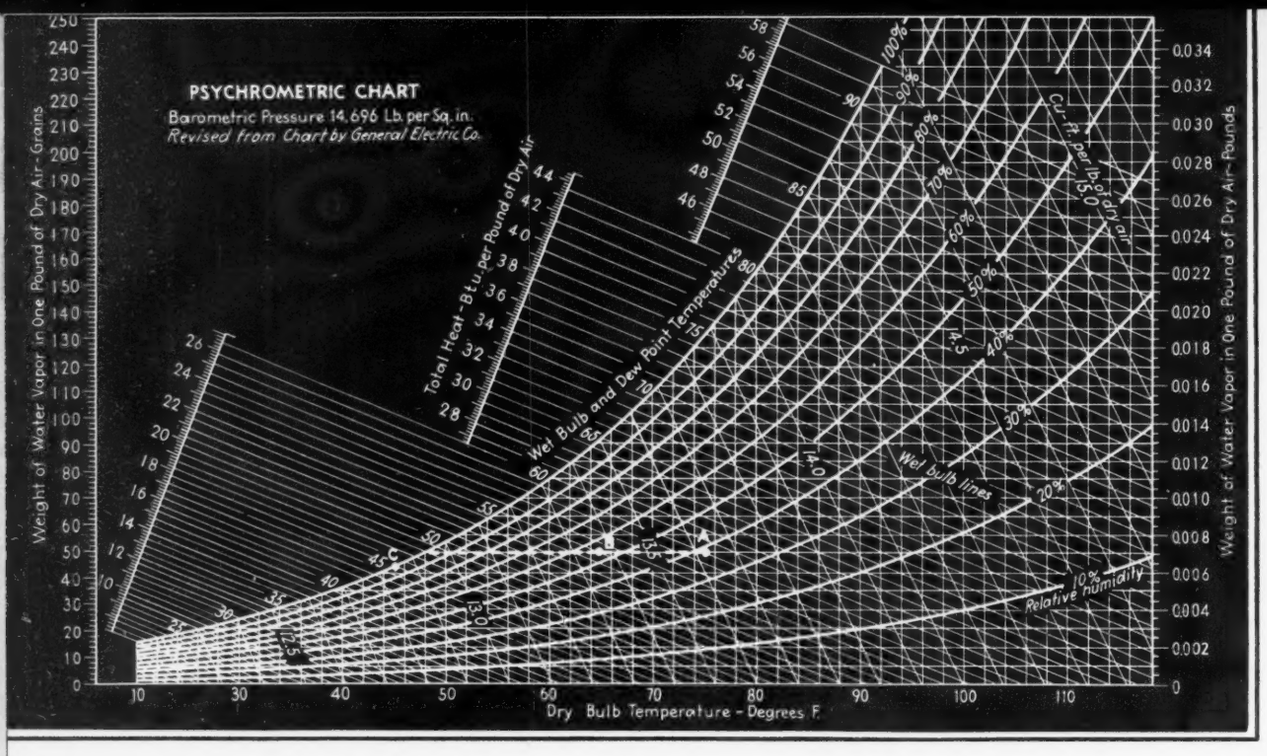
Any attempt to cool the mixture below 40 deg. will cause condensation. The temperature at which water starts to condense out of the mixture is called the dewpoint and in this case is 40 deg. As you cool the mixture below 40, the weight of water in the mixture gets less and less, but the relative humidity stays 100%—it can't get higher.

Right here we can make a practical point. Suppose you had a mixture with 0.0011 lb. of water at 80 deg. and wished to produce a relative humidity of 50% at 70 deg. You do it by overcooling and then reheating. You want to get the water down to 0.0005 lb., so you cool the mixture down to 45 deg., and all water above 0.0005 lb. must condense out. Then carry this air into a dry chamber and heat it up to 70 deg. Since there is no more water to be had, the air will reach 70 deg. with exactly 0.0005 lb. water and you'll have the desired relative humidity. This is the method of reducing humidity used in summer in most air-conditioning systems.

If a stream of unsaturated air is passed over a wetted surface, such as the towel previously mentioned, some of the water is evaporated. The latent heat necessary to turn the evaporated water into steam comes from the remaining water, consequently its temperature is lowered. The amount the temperature is lowered depends upon how dry the air is and its temperature. The wet-bulb thermometer, which consists of an ordinary thermometer with its bulb surrounded by a wetted silk gauze, makes use of this cooling effect and is used together with ordinary temperatures to determine relative

THINK OF IT THIS WAY:

1. Consider a cubic foot of moist air at 70 deg. and 30 in. pressure
2. It is simply a mixture of dry air and (generally) superheated steam
3. You have a cubic foot of steam at 70 deg. and very low pressure
4. You have a cubic foot of dry air at 70 deg. and a pressure that makes the difference between 30 in. and the steam pressure
5. If the steam is saturated the mixture is saturated—can't hold more water at that temperature
6. If water is removed without lowering the temperature, the "relative humidity" will go down in proportion
7. If the temperature is raised without adding or subtracting water, the "relative humidity" will go down
8. When the relative humidity is less than 100%, cooling (without adding or subtracting water) raises it until it reaches 100% at the "dewpoint" tempetature
9. Cooling below the dewpoint simply squeezes out water while relative humidity stays 100%
10. Water will not evaporate from an object in 100% humid air
11. Water will evaporate faster and faster as relative humidity is lowered
12. Evaporation cools, so a wet-bulb thermometer reading falls farther and farther below that of a dry-bulb thermometer as the relative humidity is reduced
13. If you know the wet- and dry-bulb temperatures you can at once obtain (from a chart) the relative humidity, the actual weight of water per lb. the dewpoint, and total heat per lb. of dry air
14. At constant wet-bulb temperature, total heat of the mixture per pound of dry air is constant and does not vary with dry-bulb temperature


PSYCHROMETRIC CHART
Barometric Pressure 14.696 Lb. per Sq. in.
Revised from Chart by General Electric Co.
Weight of Water Vapor in One Pound of Dry Air - Grains
Weight of Water Vapor in One Pound of Dry Air - Pounds
Total Heat - B.t.u. per Pound of Dry Air
Wet Bulb and Dew Point Temperatures
Wet bulb lines
Relative humidity
Cu. ft. per lb. of dry air
Dry Bulb Temperature - Degrees F.

humidity. This relationship is shown best in psychrometric charts such as the one illustrated. On the chart is shown dry-bulb temperature, wet-bulb temperature, relative humidity, weight of moisture in the mixture, total heat of the mixture and specific volume. If the value of any two of these properties is known for a given mixture, all of the others may be found directly from the chart.

In the same way that total heat of steam is all-important in power-plant engineering, so also is the total heat of air vapor mixtures important to air conditioning. That part of the total heat of air that raises the dry-bulb temperature and is associated only with the dry air is known as the sensible heat. The heat associated with the water vapor is known as the latent heat. The sum of the sensible heat and the latent heat makes up the total heat content, and is usually expressed in B.t.u. per lb. of dry air in the mixture.

Sensible heat added to any substance is equal to the temperature rise multiplied by the specific heat of the substance. For air, the specific heat is 0.24 and for any temperature change the heat involved is $(t_1 - t_2) \times 0.24$ = B.t.u. per lb. For convenience, the total sensible heat for air is considered to be the heat above 0 deg. F. Thus, for example, the sensible heat in a pound of dry air at 70 deg. is $(70 - 0) \times 0.24 = 16.8$ B.t.u.

The latent heat in the air vapor mixture has to do with the total heat in the water vapor (steam) which is easily obtainable from steam tables. Since the steam tables are based on heat above 32 deg. F. so also is the latent heat in air vapor mixtures. At the very low vapor pressures existing in air mixtures the total heat per pound of vapor is equal to $1057.2 \times 0.47\ t$, where t is the dry bulb temperature, and the latent heat in any mixture is this value multiplied by the weight of moisture per lb. of dry air. Calculation of the total heat in air mixtures, however, is not necessary as these values are given on the psychrometric charts. *The total heat per pound of dry air is the same for all conditions of the mixture that have the same wet-bulb temperature.* This property makes it possible to find total heat (above 0 deg. F.) from the chart for any condition of the air mixture.

Thus, for example, if the wet-bulb temperature is 55 deg. and the dry-bulb temperature 65 deg., we find from the chart that relative humidity is 53%, that the total heat is 23.3 B.t.u. per lb. of dry air, the weight of moisture is 0.0070 lb. per cu.ft. and the specific volume of the mixture is 13.37 cu.ft. per lb. of dry air. If this air were to be heated without allowing moisture to be added, the conditions through which the air would pass must lie on the line of constant moisture corresponding to 0.0070 lb., and if the final temperature is 75 deg. relative humidity is 38% and the total heat is 25.8 B.t.u. The heat added to bring about this increase in temperature is the difference between the initial and final total heats, or $25.8 - 23.3 = 3.5$ B.t.u.

If the air is cooled, the process is the same until the saturation line is reached. Then any further cooling causes condensation, and air conditions follow down along the saturation line. Thus if the air were cooled to 45 deg., its condition is shown at *C*. Dry- and wet-bulb temperatures are 45 deg., moisture has decreased to 0.0063 lb., and the total heat is 17.7 B.t.u. Heat removed from the mixture was $23.3 - 17.7 = 5.6$ B.t.u. per lb. of dry air, and the amount of moisture removed from the mixture is $0.0070 - 0.0063 = 0.0007$ lb. Thus you'll see that the psychrometric chart is practically indispensable to the air-conditioning engineer.

The total heat content of air-vapor mixtures is the sum of sensible heat and latent heat of the vapor. In calculating the required dewpoint temperature of the air leaving an air washer necessary to produce a desired relative humidity, it is convenient to use the ratio of latent heat load to total heat load. A chart for using this ratio was published on page 369 of July, 1935, *Power*.

If a stream of air is passed through water sprays, it will absorb moisture unless originally saturated. And if the water used in the spray is continuously recirculated and heat is neither added to or taken from the water as it is recirculated, the temperature of the water will reach the wet-bulb temperature of the entering air. When this equilibrium condition has been reached, the air will be cooled in passing through the spray so that it leaves with a dry-bulb temperature equal to the entering wet-bulb temperature and in saturated condition, assuming of course that enough spray has been provided. This is called evaporative cooling. As the wet-bulb temperature of the air in passing through the water sprays, such as in an air washer, does not change, the leaving air has the same total heat as the entering air.

In air conditioning, this process is made use of to cool the air at certain times in the Spring and Fall, and particularly when the conditioned space has considerable heat gain. It is also used in winter to obtain humidification without heating the spray water. To accomplish this, the air is heated (before entering the air washer) until its wet-bulb temperature is equal to the desired dewpoint temperature. Since, with recirculated water, the air is saturated without changing the total heat content, the wet-bulb temperature leaving will be the same as the wet-bulb entering, and the air will have with it the moisture desired.

In summer it is usually not possible to use evaporative cooling, as it makes the air too humid. To bring about satisfactory conditions, water pumped to the air washer sprays must be cooled. Usually enough spray capacity is provided in the air washer to nearly saturate the air and reduce its temperature to within a degree or so of the water temperature. By cooling the water to a low enough temperature some of the moisture is taken out of the humid summer air, and even though the air leaving the washer is saturated it has so little moisture left in it that when warmed to room temperature its relative humidity is down to 40 or 50%. To accomplish this the spray water must be maintained at from 45 to 55 deg. depending upon outside temperature.

CLEANING

Conditioned air, to deserve the name, must be free of dust, dirt, lint and odor. Cleaning saves in comfort conditioning and improves quality in process conditioning

FILTERS are used in both central and unit air-conditioning systems. In units, they are installed at the inlet to prevent dust and dirt from clogging up fin-type heating or cooling surfaces as well as cleaning air to be supplied to the conditioned space. In central systems with air washers, filters are used at the fresh-air inlet and in the return-air bypass around the washer, in the first case to keep preheating coils clean and reduce the filtering load on the washer, in the second to clean air that is not passing through the washer. Even though the air washer acts as a filter, a dry filter in the fresh-air inlet decreases the dirt in the washer water, thus decreases the frequency of spray-nozzle clogging.

The air washer, in addition to filtering dust and lint out of the return air, takes out certain odors that may have been picked up from the conditioned space, providing the spray water is kept fresh and free from odor. If the same water is recirculated continually through the sprays, the washer will not remove body odors from the air.

Filters for air conditioning are usually one of two types, the basic principles being in one case that of flypaper, and in the other the ancient labyrinth. The first type forces the air to pass through mats of split or crimped wire, glass wool, bias-cut corrugated cardboard, or expanded metal, thus breaking it up into many fine streams. On every surface it passes, there is a coating of sticky, viscous oil, so dust and dirt particles in the finely divided air streams are caught and held. The dry filter, on the other hand, sends the air through so many devious passages that the dust gets caught on the way. The filter material is usually cellulose, cotton fabric, wool felt, or hair glass. One dry filter arranged for easy cleaning incorporates a wool-felt filter glove pulled over a wire frame, forming pockets about 6 in. deep. Another uses cotton fiber pressed onto both sides of a gauze center or core. This medium is formed in V's and held in a fiberboard frame, making a unit only 1 in. thick.

Most older types of filters are washed or cleaned with a vacuum cleaner when they become dirty, but the present trend is toward throw-away types which are cheap enough to replace when they become unusable. These are usually made up in cardboard or thin-metal frames which can be slipped in and out of the supporting frame easily. They are also in standard sizes, usually 20 in. square, or 16x25 in. Thickness varies from $1\frac{3}{4}$ to $8\frac{1}{4}$ in. By bolting or fastening together a number of such units, either side to side or in a series of V's, a filter bank of almost any desired capacity can be built up.

Exceptions to this are the high-capacity filters arranged for automatic self-cleaning. These consist of an endless vertical chain or belt of filter material arranged over a top and a bottom sprocket and moving continually. Thus the chain or belt is constantly presenting new surfaces to the air stream, while dirtied sections pass downward into a tank of viscous oil that washes off the dirty oil and recoats the belt. Such an installation is fairly high in first cost, however, hence is usually used only for installations of 50,000 c.f.m. or more or where use factor is high.

If a filter is likely to collect a lot of lint, beware of the viscous-coated unit arranged for washing. The lint will not wash off easily, and if not washed off, it clogs the filter quite readily.

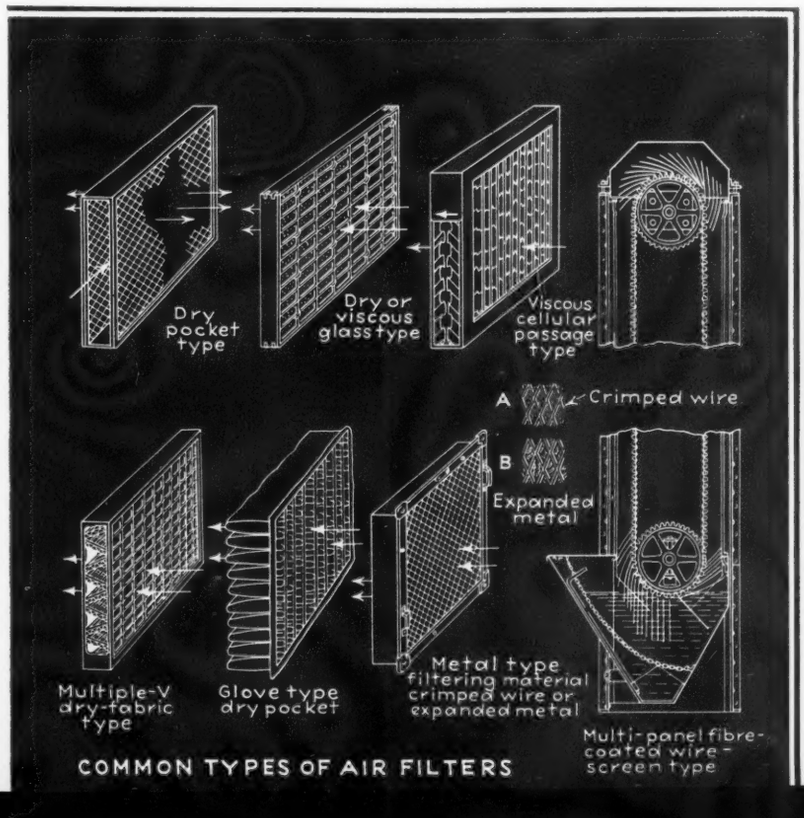
The usual filter is arranged for a face air velocity of 300 to 400 f.p.m. and a fairly low dust concentration, a 20x20-in. unit filtering 800 to 1,000 c.f.m. of air. Normal city dust loading is 0.4 to 0.8 grains per 1,000 cu.ft., industrial dust loading 0.8 to 2 grains per 1,000 cu.ft. If air has higher dust loadings, or moves at higher velocity, the increased dust loading due to greater concentration or larger volume of air handled will increase the frequency of cleaning or renewal of the filter as well as its resistance.

A good, clean filter offers a resistance to air flow of about 0.1 to 0.25 in. of water, but when it gets dirty, the figure goes to 0.4 in. This means greater resistance to air flow, and since it is a continually recurring condition, space must be provided to remove them, the duct system must be designed to take care of it and fan capacity must be large enough to take the additional load. One good way to keep from overloading fans or reducing capacity of the system due to over-dirty filters is to put a differential draft gage between filter inlet and outlet chambers. This will show when the filter requires cleaning, and the filters can then be exchanged or cleaned.

The efficiency at which a manufacturer rates his filters often depends largely upon the kind of dust or dirt he used to test it. For example, an air washer is a reasonably good filter for most dusts, but it will not take out soot—some other form of filter has to be provided for that particular job. For this reason, don't place too much faith on efficiency claims, which vary from 80 to 100%, unless you know the conditions under which the test was made.

Filter groups are like railway ticket windows in one respect—the ones easiest to get to do the most work. To avoid overloading, be sure to have ductwork arranged so that air strikes all filters uniformly. Height and length of the filter assembly ordinarily should be equal, and air should enter the filter chamber perpendicular to the filter. Usually, duct velocities are higher than allowable face velocities at the filters, so ducts must be enlarged at the filter bank. If you are short of space, it is possible to put the filters in a diagonal or *zigzag arrangement, but here again you're likely to run into that business of the railroad ticket windows—overloading of the ones easiest to get to. If it must be a diagonal installation, however, then the answer is the same as it is in a railway station—install directing vanes.

Filtering or cleaning air is the first step in air conditioning. The next is heating and/or cooling, depending upon season and installation. The next two articles discuss them.



COMMON TYPES OF AIR FILTERS

HEATING

Paradoxically, it may be necessary to heat air even in summer—if the air is cooled beyond the comfort range to take out excess moisture. And in winter, heating is essential

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FOR true all-year-round air conditioning the air must be heated during the winter, sometimes also during the summer when refrigeration of the cooling water is employed. This may seem like out-and-out waste—to expend power for refrigeration to cool the air, then turn around and use steam to heat it. But if air is cooled to obtain the desired relative humidity by condensing moisture out of it, then it must be reheated before being delivered to the conditioned space or it will cause discomfort unless unusual precautions are taken in delivering it to the space.

In most air-conditioned spaces, direct radiation is provided to make up for winter heat loss from the building. Thus the capacity of the heating surface in the air-conditioning system need only be large enough to heat fresh air as it enters the system and the mixture of fresh and returned air as it leaves the air washer up to or slightly above the temperature maintained in the conditioned space.

Heating surfaces for air conditioning are usually made up of finned tubes. Types vary with the equipment manufacturer, but are in three general groups. Some use rectangular stampings pressed onto the tubes, others use round stampings pressed on, and still others use a metal ribbon crimped at its inner edge so it spirals around the tube, then is soldered to it for intimate contact. The finned tubes are rolled into supply and return headers. Cast-iron heater sections with cast-on knobs to increase surface area may also be used, so are also illustrated.

Fin-tube heaters are usually selected so that the velocity of the air through the face area of the heater is between 500 and 700 ft. per min. With cast-iron heaters of the "vento" type, velocity through the net free area should be between 1,000 to 1,400 ft. per min. Resistance to air flow through the heating surface should in general not be more than about 40% of total system resistance.

Heating surfaces of this general type should be provided with float traps to handle the condensate. Frequently, thermostatic air vents are used either separately or in combination with the traps. Each heater should be provided with its own trap.

Control of steam to the heater is usually by a thermostat that either opens the inlet valve wide or closes it off tight. Some heaters, however, are designed to operate with a gradual-operating thermostat which throttles the supply of steam to the radiator. Such heaters are designed to distribute the throttled steam supply throughout the length of the heater, giving a practically uniform temperature to the air passing through. Unless so designed, a throttled steam flow will heat only the entrance end of the tubes, resulting in stratification of air and danger from freezing the condensate.

When an on or off thermostat is used, temperature control is obtained by a damper control which permits some air to bypass the heater and mix with the air that has been heated. Another method is to have several banks of heaters in series that come into operation as the temperature drops, thus giving step control.

In air-conditioning work, heaters are usually placed in the fresh-air inlet and are designed to heat incoming air to 35 deg. When humidity is controlled by heating the water in the air washer, this is all the fresh-air heating that is necessary. But occasionally humidity control is obtained by heating air entering the air washer to such a temperature that it will absorb the necessary moisture when passing through recirculated spray water. In this case, additional heaters are provided.

Heating coils are also provided at the discharge of the air washer, their purpose being to reheat the saturated air to the desired supply air temperature. Here again, several coils may be used in series for temperature control, or instead a bypass with damper under thermostatic control.

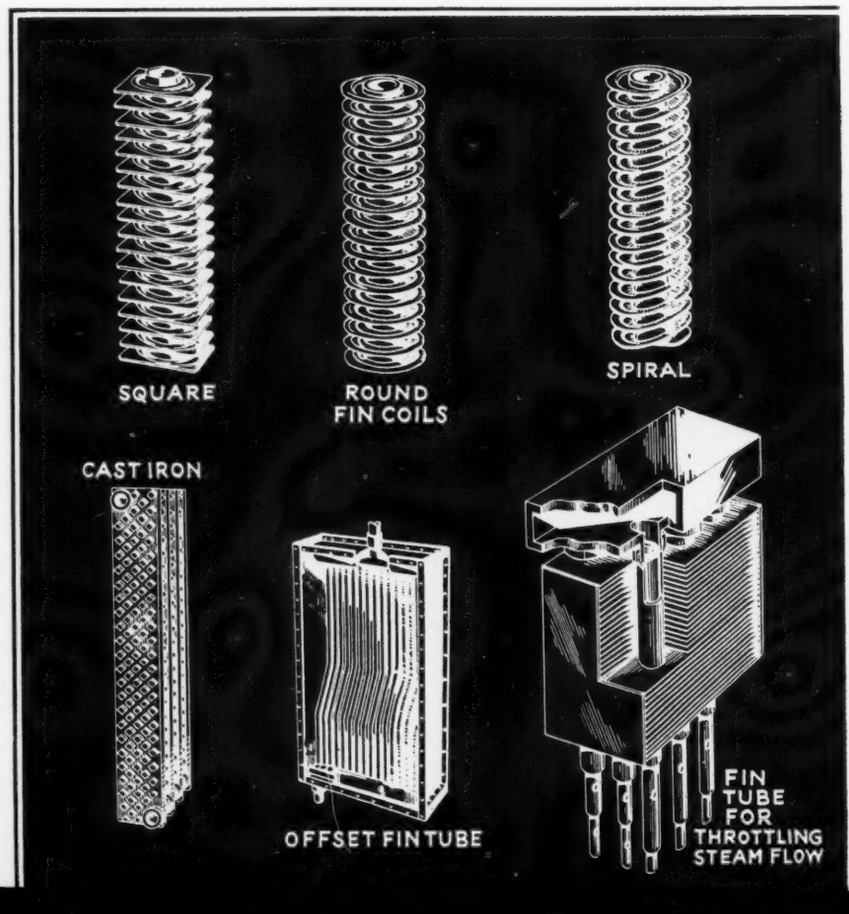
In winter, air leaves the air washer nearly saturated at temperatures as low as 35 deg. The reheater must heat the air sufficiently above room temperature to take care of heat lost in the supply ducts. The heat required per hour for practical purposes is calculated by multiplying the temperature rise by the specific heat of the air and the number of pounds of air circulated per hour. Thus, if the reheater is to raise the air temperature from 35 deg. to 73 deg., the heat it must impart per pound of air is $(73 - 35) \times 0.24 = 9.1$ B.t.u. If 1,000 c.f.m. of air are to be supplied for conditioning a room, the reheater must have sufficient surface to transfer

$$\frac{1{,}000}{13.45} \times 9.1 \times 60 = 40{,}700 \text{ B.t.u.}$$

per hr. to the air.

Capacity of fin-tube heaters is given in manufacturers' catalogs and cannot readily be estimated from dimensions.

In summer the reheating required is, of course, very much less than in winter. If steam reheating is to be used in the summer, it is well to proportion the reheater so that two banks can be used in series, thus making it possible to use one half of the heaters for summer and both for winter. Many installations of both central and unit air conditioning bypass some of the warm recirculated air around the washer and use it to raise the temperature of the saturated air leaving the washer. This eliminates use of steam for this purpose and also requires less refrigeration.



COOLING

Time was when "air conditioning" meant just cooling. Even in the newer concept of the process, however, cooling is the vital summer element

COOLING and removal of moisture (dehumidification) go hand in hand in air conditioning. Take away dehumidification, and cooling alone produces a chill, clammy atmosphere that doesn't at all meet the customer's mental picture of cool mountain breezes. Dehumidify only, without cooling, and you have dry, hot air expensively produced. It is the combination that spells economy.

When air is cooled below its dewpoint, moisture condenses out, as explained under "Humidity," page 181. This is frequently utilized by governing the temperature to which air is cooled by the amount of moisture which must be removed. To do this, the air must usually be cooled considerably below the temperature required to maintain the proper effective temperature in the conditioned space. This means too low temperature and drafts (about the same as exchanging a warm summer day for a nice drafty refrigerator) unless the air is reheated. While this seems like a waste of fuel, it is normally cheaper to overcool and reheat than to remove the moisture in other ways—the article on humidity, page 181, explains why.

Cold-water sprays, cooling-fin surfaces, sometimes ice, all are used for air cooling. Finned surfaces are about the same as those for heating (see facing page), except that the fins mustn't be so close together they prevent drainage of the moisture that condenses on them. Drip pans and drains must be provided on surface coolers to catch the moisture, supplemented by eliminators at the air outlet to prevent the air from carrying out any entrained moisture.

The finned surfaces themselves are cooled by circulating refrigerated water or brine through them, or by direct circulation of a refrigerant, such as Freon or ammonia. In the latter case, the cooler must be capable of withstanding the pressure of the refrigerant and its possible corrosive action, while in either case the cooling medium must be controlled and distributed so that the whole surface is uniformly cooled. This is a specialized problem treated more fully under "Refrigeration," pages 190 and 191.

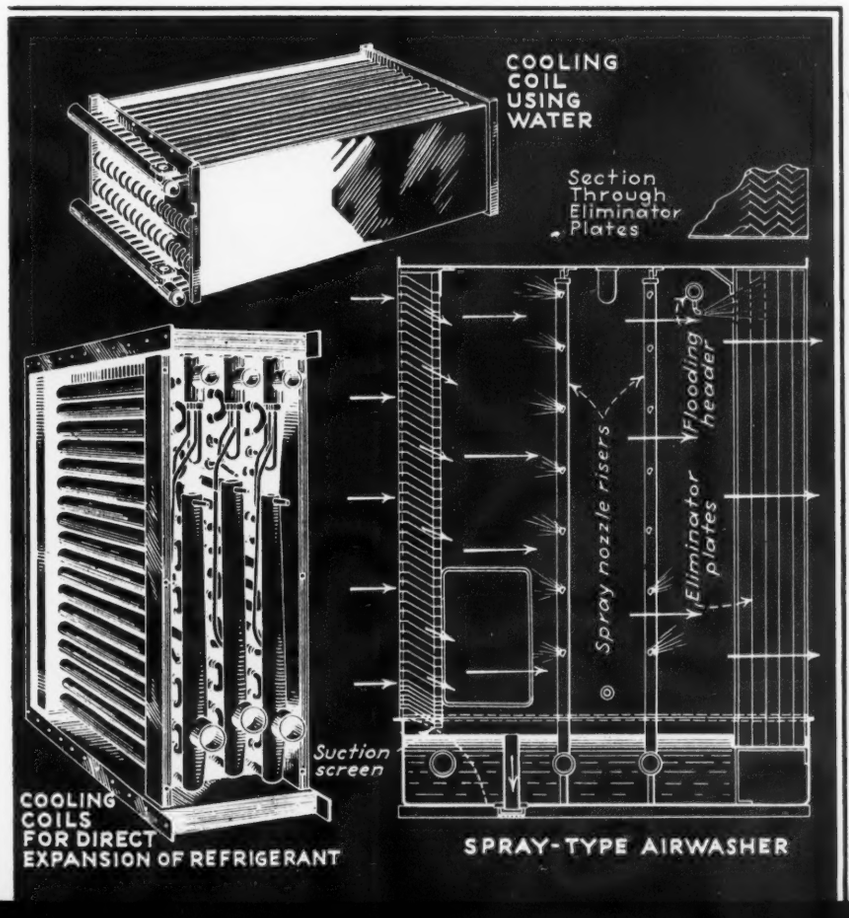
Air cooled by surface coolers generally leaves with a wet-bulb temperature a degree or two below the dry-bulb temperature, hence relative humidity is about 95%. Dry-bulb temperature, however, may be 10 to 15 deg. above the temperature of the cooling water or refrigerant. On the contrary, air leaves spray coolers at about the water spray temperature, so the spray water doesn't have to be as cold as does cooling water supplied to a surface cooler for a given outlet air temperature. The power for refrigeration is likewise less, assuming comparable operation of the refrigerating plant. But for equal capacity, air washers take up more room than surface coolers. Hence finned coils are commonly used in unit conditioners where compactness is a primary requirement, while the larger air washer is used in large installations because of its greater economy.

The typical spray cooler or air washer shown (others are diagrammed in "Moistening," next page) is just a metal tank or reservoir with two banks of spray heads over it arranged to spray into the air as it passes through. Zigzag eliminator plates just behind the sprays prevent the air from taking out any entrained moisture, and the galvanized metal sheeting which forms the enclosure forms a water-tight duct, in both cases to avoid a fine mist from the outlet.

Usually a pump takes water from a cooled-water reservoir and sprays it through the heads, although safety considerations and city ordinances permitting, it is possible to place water-cooling coils cooled by a refrigerant directly in the washer. This requires a separate pump to spray the water over the cooling coils, but has the advantage that the amount of water circulated controls spray-water temperature as desired. Normally, water is cooled in a separate cooler and supplied to the washer through a 3-way mixing valve at the suction of the spray-water circulating pump.

In certain circumstances—i.e., when load factor is very low or ice is very cheap—it is economical to use ice for cooling. The air is circulated over the ice directly, or the ice may be dumped into the cooled-water reservoir and the water then pumped out to a surface cooler.

In a foundry, forge shop, etc., where furnaces, ovens or other equipment add considerable heat to the air, some cooling effect can be gotten by bringing in outside air through an air-washer, using evaporative cooling to bring the dry-bulb temperature of the incoming air down to its wet-bulb. For example, let's assume outside air at 80 deg. and 50% R.H. (wet bulb about 67 deg.) is passed through an air washer in which the spray water is continuously recirculated. The air will pick up water, dropping its dry-bulb temperature to within a degree or two of its wet-bulb, say in this case to 70 deg., and making it nearly saturated. Now, if a comparatively large volume of this air is passed into the room, large enough to limit the temperature rise to less than 6 deg., the final room temperature will be 76 deg. with about 70% R.H. This reduces *effective temperature* only 1 deg. below outside conditions, but it is 5 deg. lower *effective temperature* than would exist in the room if the same volume of air were circulated without using an air washer. And 5 deg. effective temperature helps a lot (page 180).



MOISTENING

Called "humidifying," the process of moistening air is usually needed only in winter, except in industrial processes which demand a humid atmosphere the year round

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FOR comfort conditioning, humidification is required only during the winter, and in cold weather it is advisable not to attempt to maintain a relative humidity over 20 to 30%. Attempts to carry higher humidity only cause trouble because moisture condenses out on cold surfaces such as windows. For example, with an outside temperature of 20 deg., moisture starts to condense on windows with inside conditions of 70 deg. dry bulb and 25 deg. relative humidity. Some manufacturing processes require high humidities for best product quality as indicated on page 180. Under such circumstances, either moisture must be introduced into the air faster than it will condense, or room temperatures must be lowered, or windows must be blanketed with a blast of heated air. Such installations require careful and experienced engineering.

Practically all central air-conditioning systems use the same air washer for winter humidifying that is used in summer for cooling and dehumidifying. One type of washer thus used is shown in the drawing. As in the washer illustrated on the preceding page this washer consists of a spray chamber and tank into which the spray falls and collects. Water is delivered from a single nozzle to the center of a rapidly revolving motor-driven rotor by gravity or by pump. The rotary motion distributes the water evenly over the surface of the rotor and causes it to flow to the periphery, where it impinges against pins which churn the water into a fine mist. Eliminators, of course, are provided at the outlet of the washer to prevent carry-over of moisture, and entrance louvres help to distribute the air evenly over the washer. When humidification only is required, as for industrial use, only one motor-driven rotor is necessary, but for all-year air conditioning two rotary atomizers, as shown in the illustration, are usually used.

The amount of moisture carried with the outgoing air may be controlled either by heating the spray water to the desired dew point temperature or by preheating the air before it enters the washer and recirculating the spray water. The degree of preheating required to obtain a desired leaving dewpoint may be determined from the fact that the total heat in a pound of entering air does not change in passing through the washer, as explained in the article "Straight Thinking on Humidity," pages 181 and 182. Thus it is only necessary to heat the air entering the washer until its wet-bulb temperature is the same as the desired dewpoint of the air leaving the washer.

This preheating may be done in two ways. One method is to install two sets of preheating steam coils in the fresh-air inlet, one to heat the air to just above freezing and the other to raise its temperature to the temperature required to obtain the proper humidity. The other method is to heat the fresh air with only one set of preheating coils to above freezing and do the rest of the heating by mixing with the necessary amount of recirculated air.

Both closed and open heaters are used to heat the spray water. The open heater injects steam through a mixing valve directly into the water, whereas in the closed heater the steam and water do not mix. The open heater sometimes gives the water a characteristic steam smell that may be objectionable. Heat to be supplied is equal to the difference between the heat in the air leaving and entering the washer and usually amounts to about 7 B.t.u. per lb. of air.

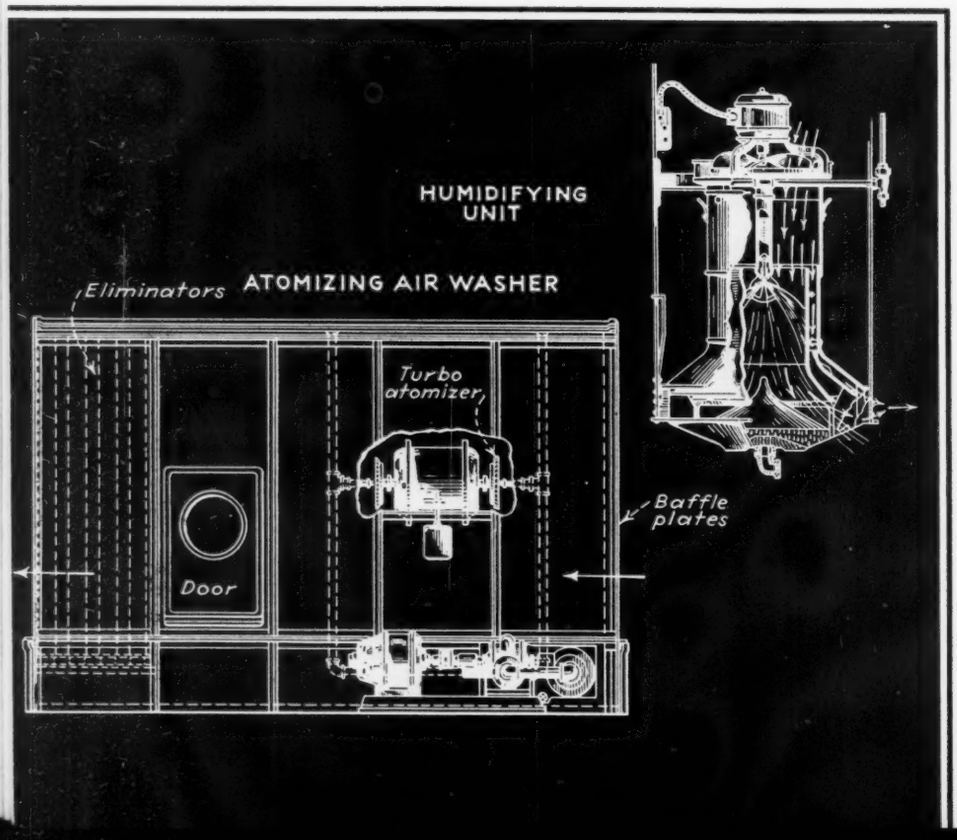
Air washers are always installed with the supply fan at the washer outlet so that it draws air through the washer. This arrangement is used because it makes possible more uniform distribution of air over the washer cross section which would be difficult to secure with the fan blowing through. Sometimes perforated plates or louvres are used at the washer inlet to improve distribution.

With surface-type cooling coils, if winter humidification is desired it is necessary to provide some means for adding moisture to the air. Three methods are in general use. One of these uses pans arranged so heated air causes evaporation of water contained in them. A second employs finely atomized water spray, and a third uses wetted fabric or other surface around which air flows.

Pan-type humidifiers are used to a considerable extent in unit conditioners. They are arranged so that the water supply is controlled by float valve. The pans should be emptied and cleaned regularly, as dust tends to collect on the surface and impurities in the water collect in the pan as the water evaporates. For the same reason, wetted fabric or surface humidifiers should be cleaned frequently. When sprays are used, a drip pan and drain are necessary to catch excess water not absorbed by the air.

Where high humidities are required in industrial establishments spray-type humidifiers, such as illustrated, are often used. A number of such units hung from the ceiling are arranged to obtain uniform distribution of the moisture added to the air. The one illustrated has a propeller-type fan that blows room air down through a heated water spray produced by an atomizing nozzle. The air is made to turn 90 deg. and is delivered horizontally in all directions.

Probably the simplest means of adding moisture to the air is with direct use of steam. But steam is not used for comfort conditioning because of the disagreeable odor usually accompanying it. It is used frequently in industry, and is usually introduced through a perforated tube.



DRYING

Called "dehumidifying" by air-conditioning engineers, drying is a necessary companion to air cooling, because as air is cooled it becomes relatively wetter, hence feels clammy

COOLING alone does not create comfortable and healthful conditions in most parts of the country. As explained in the article on "Humidity," cooling air raises its relative humidity, thus making it feel clammy and not at all comfortable. For example, if air at 85 deg. and 60% relative humidity is cooled to 75 deg., its relative humidity becomes 85%. To make it feel right again to occupants of an air-conditioned space, some of the moisture must be taken out, to lower its relative humidity to the comfort range.

How much moisture has to be removed, and what relative humidity should be maintained? To answer these questions, we must first have answers to some others. Is conditioning undertaken to maintain comfort or to improve a manufacturing process? How much moisture is given off in the conditioned space? What are outside weather conditions? Industrial air-conditioning requirements vary over a wide range, as indicated in the article, "Why Air Conditioning." For comfort condtioning, relative humidity should be between 40 to 60%, assuming, of course, that effective temperature is maintained within the comfort zone. People in a room give off moisture, as do certain processes, heated foods, steam tables in restaurants, etc. Research has provided data which indicate how much moisture is being added in the conditioned space.

Cooling and drying, go hand in hand. In fact, most conditioning installations dehumidifying by cooling below the dewpoint, so causing moisture to condense out of the air. Temperature to which air must be cooled is determined by the relative humidity desired and the amount of moisture given off in the conditioned space. For example, if a relative humidity of 55% and dry bulb of 75 deg. is required, air must be cooled to 58 deg., assuming no moisture is added in the conditioned space. If moisture is added (and it usually is) air must be cooled to a lower temperature.

Air may be cooled by air washers, surface-type coolers or ice. All methods are in use for both dehumidification and cooling. They have been discussed on page 185.

Another method of removing moisture from air involves chemicals that have great affinity for moisture. Those used make use of adsorption, in which process the chemical has the property condensing and holding water vapor on its surface without change of chemical or physical structure. This process is accompanied by liberation of heat, hence, the highly dehumidified air is subsequently cooled by surface coolers using cold water, or by partial rehumidification, or a combination.

Chemicals used in adsorption systems include solids such as silica gel, activated alumina, and liquid adsorbents such as solutions of calcium chloride and lithium chloride.

Chemical methods of dehumidification have found particular application where extremely dry air is necessary. One system of this type is known to dry the air to a moisture content of 0.43 gr. per lb. of dry air. But the applications most suited to chemical drying are known best by the manufacturer.

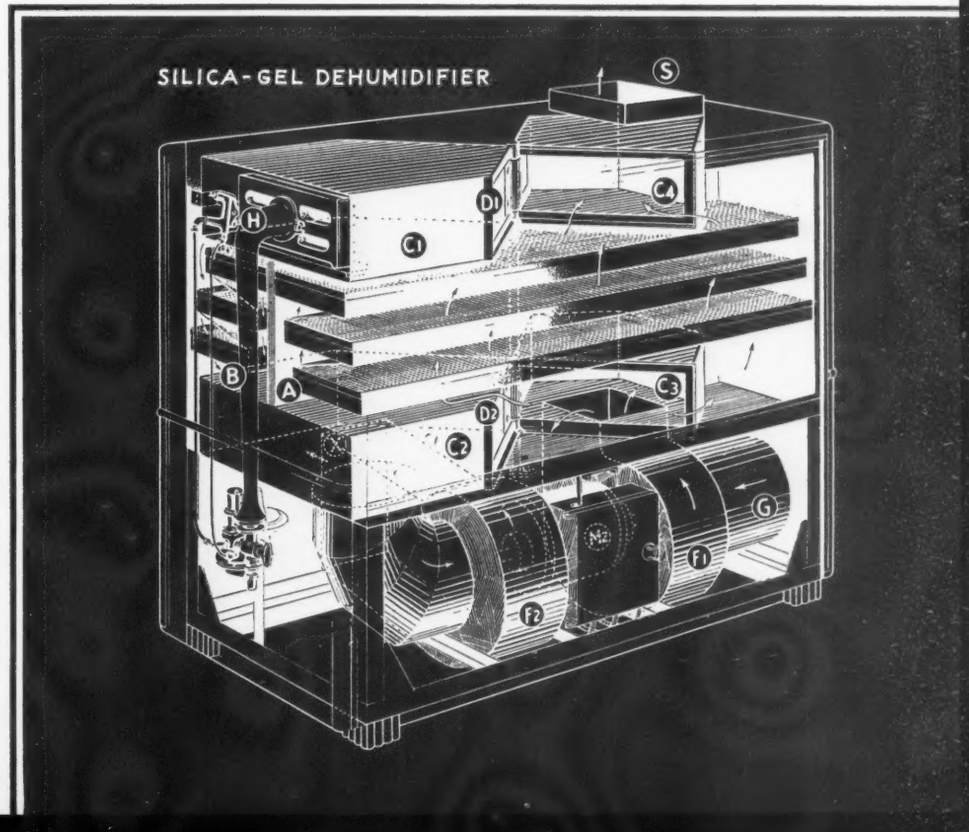
Illustrated is an adsorption system using silica gel, which is a colloidal form of silicon dioxide, a hard glassy material with the appearance of clear quartz sand. In this form it is extremely porous, and its pores catch and hold water vapor from air which passes over it. After it has caught as much vapor as it will hold, it can be heated to drive the moisture out, making it ready again to adsorb moisture. Thus, if it is put into a 2-compartment unit, one side can be used to take water vapor from the air while the other is being heated to drive off the adsorbed moisture.

There are two compartments containing silica gel in the unit illustrated. Each has three trays on which adsorbing material is supported on screens and staggered so that part of the air passes through each bed of silica gel. While one compartment is adsorbing moisture, the other is being reactivated. Air being dehumidified passes upward through the beds while air for reactivation passes downward.

Above and below the gel beds are compartments containing twin 2-position 4-way dampers mounted on the same shaft and controlling air flow.

Hot reactivating air from gas burner *H* is drawn through chamber C_1, and with damper *D*, closed, passes down through *B* bed of gel into chamber C_2 to exhaust fan F_2. At the same time air being dehumidified is drawn in through *G* by fan *F*, and discharged through C_3 to pass upward through bed *A* into C_4 and out to the supply duct at *S*. Dampers are shifted automatically once every 10 min. While one gel compartment is dehumidifying for 10 min., the other is being reactivated for 7 min. and cooled for 3 min. The gas burner heats the reactivating air to about 300 deg. and is equipped with an off-and-on valve which may be under the control of a room humidistat.

Systems using other solid chemicals operate on the same principle, using two or three compartments of chemicals, one or two acting as the adsorbent while the other is being reactivated. Liquid adsorbent is used as a spray through which the air passes. The spray is caught by eliminators and receiver tank and pumped to a regenerator where heat is applied to reactivate it, after which it is again pumped to spray nozzles. This results in a continuous cycle requiring no dampers or timing device.



MOVING

Conditioned air, like any other commodity, must be taken from point of manufacture to point of use. Fans and ducts serve the purpose. How are they selected to do their job?

•

THE unit-conditioner fan draws air through the conditioner and delivers it with sufficient velocity to cause air circulation in the room. But the central system must also collect exhaust air and return it through ducts to the unit, so it usually has two fans, a supply fan close to the unit which forces conditioned air to the point of use and an exhaust or return-air fan to bring it back.

Selection of fan size and location, and of ducts and the rest of the system for that matter, must be based upon a knowledge of the quantity of air to be handled. Two factors govern this, first the amount of sensible heat it must absorb in conditioning the space, the second the permissible temperature difference between the entering supply air and the desired room temperature. (A blast of icy air cools a room, but it's hard on occupants).

The amount of sensible heat to be absorbed is fixed in turn by the type of building being conditioned (how fast do walls, windows, and doors transmit heat and occupants emit it?—see "Refrigerating," page 190), and by the temperature that must be maintained with respect to outside conditions. Thus the only variable in the problem is the difference between supply air and room temperature. This varies from 8 to 20 deg., depending on room construction and how air is introduced (See "Delivering," page 192).

Once the allowable temperature difference is determined, the volume of air to be circulated is calculated from this formula:

$$c.f.m. = \frac{56 \times (\text{B.t.u. sensible heat to be removed per min.})}{\text{Room temperature} - \text{supply temperature}}$$

The supply fan must be capable of delivering this volume, and usually has a capacity 10 to 20% greater. The exhaust fan generally has 10 to 15% less capacity than the supply fan so as to maintain a slight pressure in the conditioned space and thus prevent infiltration of outside air. This is particularly important in conditioning such spaces as restaurants, where infiltering air may bring with it odors from the kitchen.

We now have air volume determined. The next step is design of the duct system, for this too influences fan selection. Duct size, proportions and length are all factors which affect friction resistance to air flow, and this resistance, if abnormally high, may force installation of an oversize and uneconomical fan.

Noise is almost certain to crop up where ducts are too small in cross-section to keep air velocity at a reasonable figure, too light in construction (hence prone to vibration), or with constricted or poorly proportioned spots which cause local high velocities and attendant vibration and noise. It is generally considered good practice to use velocities of 1,200 to 1,600 f.p.m. in the main duct, but only 600 to 1,000 f.p.m. in branch ducts. If noise doesn't matter velocities may go up to 2,000 or 2,500 f.p.m.

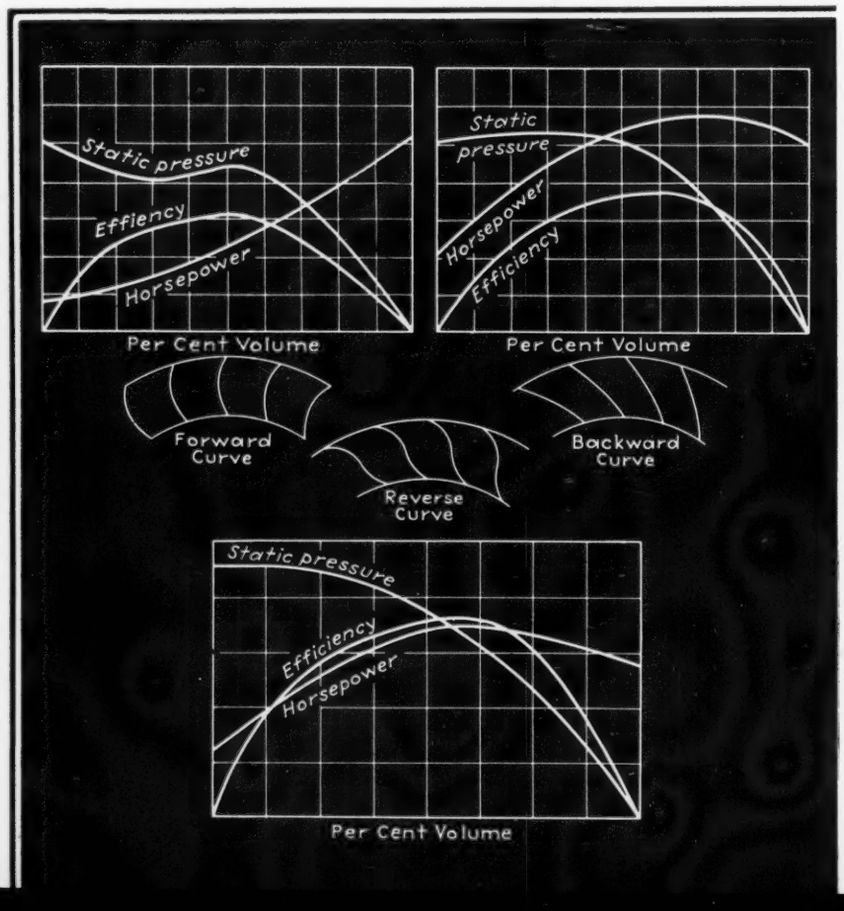
The velocities chosen have important bearing on friction, as has the general layout and design. Generally speaking, the ducts should run as direct as possible to the job. In cross-section they should be as nearly square as building conditions permit, and one dimension should never be more than 10 times the other. Avoid short-radius bends, but where necessary, decrease their resistance by installing directing vanes.

With the ducts designed, frictional resistance can be calculated from data and methods given in handbooks and texts. To this resistance must be added, of course, the friction resistance given by the manufacturers of the various elements of conditioning equipment, such as filters, air washers and heating coils. With this obtained, fans can be selected.

Three types of fans are widely used in air conditioning, distinguished from one another by the curvature of their blades with respect to wheel rotation. The types, illustrated below, include the forward-curved blade, backward-curved blade, and forward-and-backward-curved blade, a combination of the other two. The main difference in the characteristics of these fans is that the forward-curve type has a flatter pressure characteristic at higher pressures, but it has a hump in it, and a horsepower curve which keeps going higher as the volume of air handled is increased. The hump in the characteristic curve of the forward-curved fan does not mean that it can deliver two different volumes of air with the same static pressure, (See *Power*, Jan., Feb., 1936). Likewise with proper analysis it is perfectly possible to prevent motor overloads with the forward-curved fan even though it does not have the limiting horsepower consumption of a backward-curved fan.

In selecting fans, a major consideration is the type of drive to be employed. Will it be direct connected to an electric motor or driven through belt or some other power-transmitting device, or will it be driven by turbine or engine? With this in mind, remember that a backward-curved fan operates at a peripheral speed approximately 2½ times that of a forward-curved fan, hence for the same static pressure its speed is more adaptable for direct connection to an electric motor. But lineal dimensions of this type average 25% and cubical space 100% above that required for forward-curved fan. Efficiencies are substantially the same.

To summarize: select fans so that the system-resistance curve will pass through the pressure-volume characteristic curve at approximately the point of best efficiency (See the graphs). For best operation, determine system resistance and required volume as carefully as possible. These figures must not be padded or factors of safety applied, for trouble will surely follow from noise or inefficient operation.



MIXING

Fresh air must be mixed with return air, washed air with bypassed air, and conditioned air with room air. The latter is discussed in "Delivering," page 192. Here are the others

AIR at one temperature and relative humidity must be mixed uniformly with that at another temperature and relative humidity in at least three places in air conditioning. The major mixing occurs when newly conditioned air is introduced into the space to be conditioned, and is a specialized problem discussed in "Delivering," page 192. The other two mixing points are at the inlet and outlet of the air washer in a central system (or at the inlet to a unit conditioner).

At the inlet, return air from the conditioned space is mixed with fresh outside air. During the summer the resulting temperature and humidity is of little importance, but in winter it may be used to control humidity (See "Moistening," page 186). At the washer outlet, washed air is often mixed with air bypassed around the washer to raise its temperature enough to permit its introduction into the conditioned space without causing discomfort to occupants. At both places we must know what the final conditions will be, in order to control them by changing proportions of the elements.

In the first case, the problem is simple—it merely involves averaging. For example, suppose we wish to find the final conditions when 1,000 lb., of fresh air at 35 deg. and 50% R.H. mixes with 2,000 lb. of return air at 70 deg. and 30% R.H. The psychrometric chart shows that 35-deg. air has a wet-bulb temperature of 20.5 deg., its total heat is 10.8 B.t.u. per lb., and it carries with it 0.00221 lb. of water vapor per lb. The 70-deg. air has a wet-bulb temperature of 53 deg., a total heat of 22 B.t.u. per lb., and carries 0.00464 lb. of water vapor per lb.

The air at the lower temperature contains a total of $1{,}000 \times 0.00221 = 2.21$ lb. of moisture. The air at the higher temperature has a total of $2{,}000 \times 0.00464 = 9.28$ lb. of moisture. The mixture must have the sum of these two quantities, or $2.21 + 9.28 = 11.49$ lb. This weight of water vapor is contained in 3,000 lb. of the mixture, so each pound of mixture must have $11.49 \div 3{,}000 = 0.00383$ lb. of water vapor. Similarly, the total heat per pound of the final mixture may also be found, and is $\frac{(1{,}000 \times 10.8) + (2{,}000 \times 22)}{3{,}000} = 18.26$ B.t.u.

These two conditions are sufficient to locate the final condition on the psychrometric chart, from which we find that the wet-bulb temperature is 46.2 deg. and the dry-bulb temperature 58.4 deg.

If in following this example, the points representing the two initial conditions and the final condition were marked down on the psychrometric chart at *F*, *B* and *E* they all will be found to lie on a straight line. In fact, the final condition can be found graphically from the chart by connecting the two initial points with a straight line and dividing the distance between the points in reverse proportion to the mixture. That is, the final condition in the example is one-third the distance between the initial points from the higher-temperature air, and two-thirds the distance from the lower-temperature air, whereas the mixture was 2 parts of the high temperature air to 1 of the low.

Suppose on the other hand we wish to find how much return air to mix with the air leaving an air washer in order to heat it to a temperature permissible for supply air. Although the same principle of mixtures is involved, the procedure is not as easy and is best explained by an example. A room is to be maintained at 78 deg. and 50% R.H. and the supply grilles and room dimensions are such that the temperature at the supply inlet must not be less than 68 deg. The heat load is such that the ratio of sensible heat to total heat requires the entering air to have a dewpoint temperature of 55 deg., and 3,000 lb. per min. of supply air is required to produce the room conditions given.

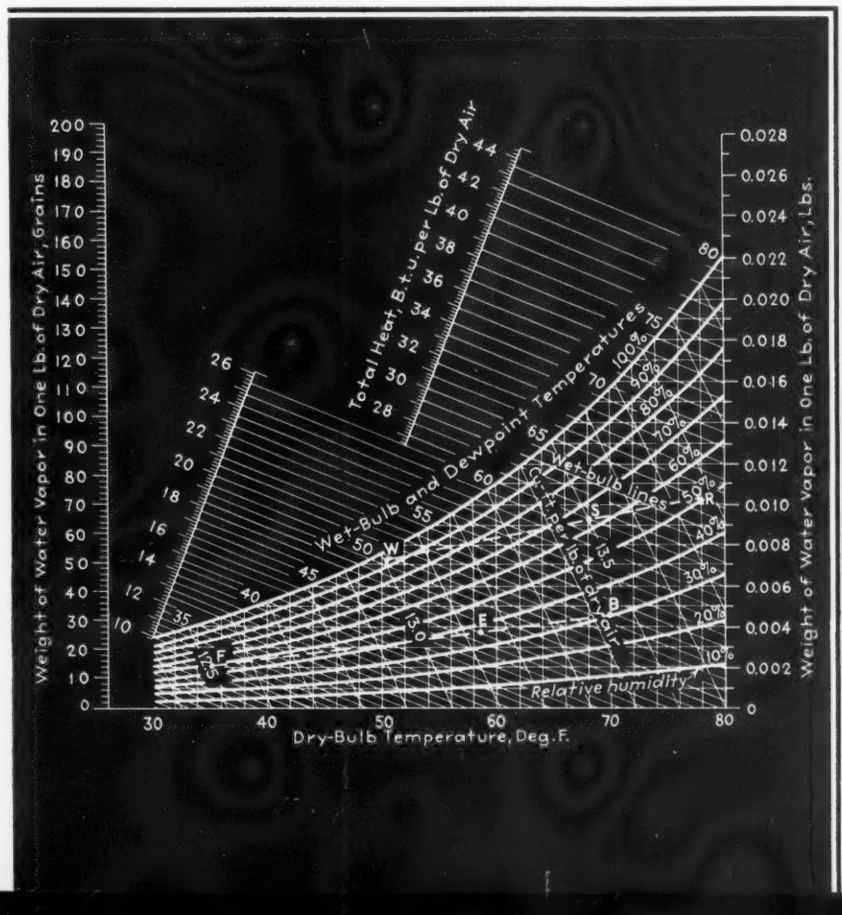
How much of this air must go through the air washer? How much is to be bypassed? Before either of these questions can be answered it is necessary to find the temperatures at which the air must leave the air washer in order that the final mixture will have the desired dewpoint. This requires a cut-and-try process, but it can be found graphically on the psychrometric chart quite easily. When air is mixed, the two initial conditions and the resulting condition all lie on a straight line drawn through these points on the psychrometric chart. In this case we know the final condition and one initial condition (return air and room conditions are assumed the same). The other initial condition, that leaving the air washer, must be on the straight line connecting the other two points (*R.* and *S*). Since the air leaving the washer will have a relative humidity of about 95%, the intersection of 95% relative humidity with the line drawn, point *W*, determines the outlet temperature as 50.5 deg. dry-bulb and 49.8 deg. wet-bulb, with a total heat of 20.2 B.t.u.

With the condition of the air leaving the the washer determined, the amount of bypass air can next be found from the equation:

$$W_B = \frac{W_T\ (H_s - H_a)}{H_B - H_a}$$

where W_B is the weight of bypass air per min, W_T the weight of total supply air per min., H_s the total heat of the supply, H_a the total heat of air leaving the washer and H_B the total heat in the bypass air. In the example, $H_s = 26.5$ B.t.u., $H_B = 30$ B.t.u. and $H_a = 20.2$ B.t.u. Then $W_B = \frac{3{,}000\ (26.5 - 20.2)}{30 - 20.2} = 1{,}930$ lb. per min. of bypass air and $3{,}000 - 1{,}930 = 1{,}070$ lb. of air per min. through the washer.

Next problem is refrigeration—type, size, and capacity. . . .



REFRIGERATING

In "Cooling," page 185, and in "Drying," page 187, mention was made of the need for refrigeration in air conditioning. Here are described types and systems, with some analysis of load

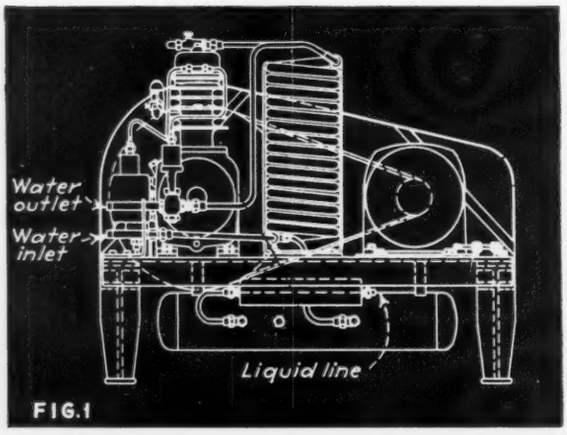


FIG. 1

JUST as heat must be added to the air during cold months, it must be taken away during warm periods before any claim to complete air conditioning is justified. Where does this heat come from? The air around us is usually the main source of heat, but there are many others, for example, electric lights, machines, occupants, heat liberated by processes and—not so simple, latent heat in water vapor removed by drying (*Power*, Feb., 1935, p. 76). Heat from the atmosphere shows itself in three ways: (1) heat transferred through building walls because of the higher outside temperature, (2) heat brought in with outside air through cracks and open doors and windows, and (3) heat radiated by the sun through windows and skylights to objects in the building.

Heat produced by electric lights is the simplest of all factors involved in the refrigerating load. Since all power supplied to a lamp eventually appears as heat, the rating of the lamp, in watts, times 3.4 gives B.t.u. per hr.

Industrial load, heat from machines and processes, must be calculated from a knowledge of the individual machine or process. For example, the heat from an electric motor is equal to 3.4 x rated watts x (100—% Efficiency). On the other hand, if the motor and the driven machine are both in the room, as on a printing press, all of the energy input eventually appears as heat. Then the B.t.u. per hr. produced is equal to the rated watts of the motor times 3.4. In many instances it is easier to measure the energy that leaves the space than the efficiency. Where this is so, the difference between the input in watts and the power that leaves the building x 3.4 equals the B.t.u. per hr. produced. Following this line of reasoning, it is usually possible to arrive at a close estimate of the heat produced.

Occupants add to the refrigeration load in two ways, by actual radiation and convection of heat from the body (sensible heat) and by heat in water vapor added to the air (latent heat). Tables and charts published by the A.S.H.V.E. give in great detail the heat given off by the human body under various conditions of temperature, humidity and activity. As rough approximations, it is safe to use 400 B.t.u. per hr. per person for people at rest and 700 for people doing mild work.

Heat removed in drying air is discussed in "Straight Thinking on Humidity" page 181, so nothing further need be said about it here except to note that it is an important part of the refrigerating load.

The effect of the atmosphere depends to a large extent upon geographic location and construction of the building. If it gets hot outside, the windows don't fit well, the walls aren't adequately insulated and a hot sun shines through skylights and windows, the load on the refrigeration plant is bound to be high. Heat transmitted through walls and the effect of the sun's radiation can only be determined by using factors based on actual tests and experiments. The A.S.H.V.E. has made these observations and published the results in its *Transactions*. By using factors which apply to the particular conditions, the atmospheric load can be calculated.

The sum of all B.t.u.'s produced per hr. by sources outlined above divided by 12,000 gives the tons of refrigerating load. To this add the additional refrigeration required by the particular drying process employed to obtain the capacity of the refrigerating plant.

As mentioned in previous articles, heat can be taken away by three types of refrigerating systems in air conditioning. First is the unit system which employs relatively small yet complete units distributed about the space to be conditioned. Second is the central-plant system wherein all equipment is concentrated in one area, the air being distributed through ducts. This is the same as the central heating system and has most of its advantages. The third system is a combination of the first two, where, for example, cold water from a central refrigeration plant is piped to local conditioning and circulating units. Occasionally, sufficient well-water can be secured at a very low cost. Where this is possible it eliminates the refrigerating plant.

Fig. 1 is a typical small-size air-conditioning condensing unit, factory fabricated, requiring only electrical, plumbing and refrigerant connections on the job. In most cases these units have reciprocating compressors belt driven by electric motors. Compressor, motor, air- or water-cooled condenser, liquid receiver, trap, refrigerant filter and control are mounted on a single base and usually inclosed in some sort of ventilated cabinet. Common refrigerants for unit conditioners are Freon and methyl chloride.

In the central system there are various methods of producing refrigeration. The simplest uses ice (Fig. 2) and is called a "melter." Water from the air washer is sprayed over cakes of ice in a box or tank with about 60 cu.ft. per ton of ice. A 3-way diaphragm valve in the return line operated by a thermostat in the line to the air washer, set for water temperature required, bypasses some of the water around the melter if necessary. This method is suitable for rather small installations and where ice is cheap, readily obtained and the use factor is low.

The steam-jet system (Fig. 3) is finding increasing popularity. It is especially economical where steam-generating equipment is already installed or where exhaust steam from high-pressure machines is available. Its usefulness depends on the fact that the temperature of the circulating medium is comparatively high for air-conditioning work. Water to be cooled is sprayed into the evaporator, where it boils at the high vacuum corresponding to the temperature to which it is to be cooled. A steam jet maintains the high vacuum and compresses the vapor from the boiling water to the pressure maintained in a condenser. The condenser provides a vacuum into which the steam jet exhausts (so reducing the extent to which it must compress the vapor), and condenses the steam and vapor. A dry-vacuum pump removes air from the condenser.

Water is used as the refrigerant, hence possibly dangerous or costly refrigerants are not required. Moving parts are few—only the rotors of the centrifugal pumps move.

The quantity of cooling water required, however, is about three times as much as for other types of refrigerating systems.

Mechanical methods of producing cold make use of reciprocating or centrifugal compressors. With a reciprocating compressor (Fig. 4), the liquid refrigerant enters the cooler through an expansion or float valve. In the cooler, heat from the water causes the refrigerant to boil. Vapor from the boiling refrigerant is removed by the compressor and the pressure raised to that required for its condensation in the condenser at the temperature of the available cooling water. From the condenser, liquid refrigerant collects in the receiver.

Reciprocating compressors are often driven by synchronous motors or some other constant-speed device, hence some method of varying capacity other than speed control must be used. The most common method is to provide clearance pockets on the compressor. If the compressor is driven by a steam engine or a d.c. motor, speed control is practical and clearance pockets are not needed. Load fluctuation can also be provided for by using a number of small compressors. However, small units are more expensive than large, and duplication of auxiliaries gives this method a high first cost.

Four refrigerants in general use with reciprocating compressors are: ammonia, carbon dioxide, dichlorodifluromethane (Freon) and methyl chloride. Ammonia is used principally in industrial installations, where the effect of leaks is not important. It is toxic (0.25 to 0.45% by vol. for 30 to 60 min. being dangerous) but its odor gives adequate warning. It is only slightly inflammable, in that a large percentage of the gas is required to burn in air. It has a higher specific heat content than any other refrigerant except water. Carbon dioxide involves higher pressures than any of the other refrigerants (meaning more-expensive piping and machines), and some efficiency is lost when condensing-water temperature is high, but it is used to a considerable extent in public buildings because of its non-toxic character. Freon, under normal conditions, is non-toxic, non-irritant and non-explosive, but in contact with flame it may break down to several toxic components. It has a lower latent heat than the other refrigerants, consequently a greater weight of it must be circulated per minute per ton of refrigeration. But its specific volume is low, and theoretical displacement of a compressor is thus about 1.7 times as great as for ammonia. Methyl chloride is used mostly in small units.

The greatest advantage of centrifugal refrigeration systems is that they utilize synchronous motors or steam turbines and yet have a variable capacity. Just as with the centrifugal pump, the capacity of a centrifugal compressor can be varied by simply opening or closing a valve or damper. Operation of a centrifugal system can be seen in Fig. 5. Vapor formed by heat from the circulating brine in the cooler passes through the eliminator and damper to the compressor. The compressed vapor is condensed by passing over cooling-water coils in the condenser. The difference in pressure between the condenser and cooler causes enough liquid to evaporate in the cooler to lower the temperature of the remainder to a point corresponding to the pressure. Air which leaks in due to the vacuum under which the entire system operates is evacuated by the high-temperature evacuator. The economizer takes heat away from the compressor to gain the greater economy of isothermal compression.

Since centrifugal compressors are particularly suited to large changes in volume and relatively low compression ranges they require refrigerants which evaporate and can be compressed to liquids below and at atmospheric pressure. Some of these are: Dielene (Dichloroethlene), Carrene (Dichloromethane) and Carrene No. 2 (trichlorofluoromethane). Since all of these operate under a vacuum, inward leakage of air and water vapor cannot be completely eliminated. Hence, vacuum pumps, operating intermittently, must be used to maintain the required pressure.

Ethyl bromide is another possible refrigerant for centrifugal compressors, but is not used to any great extent because it is toxic. Water is also successfully used in centrifugal compression systems and may become more popular since it is so safe—in fact, a centrifugal compressor for water-vapor refrigeration was described in *Power*, Feb., 1934, Page 93. Such a machine must compress large volumes of water vapor to condensing pressures corresponding to the temperature of the cooling water available.

Detailed working out of a refrigeration system is, just as is detailed design of an air-conditioning system, an operation requiring experience and specialized knowledge. This article, as have others in this section, thus endeavors only to outline the subject. Next we cover delivery and control, then pass to final inter-connection of all the elements of the air-conditioning system, "buttoning up the job" again.

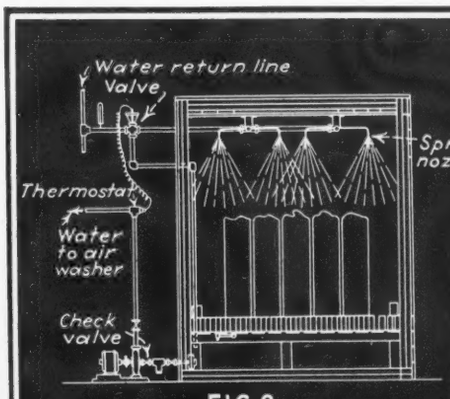


FIG. 2

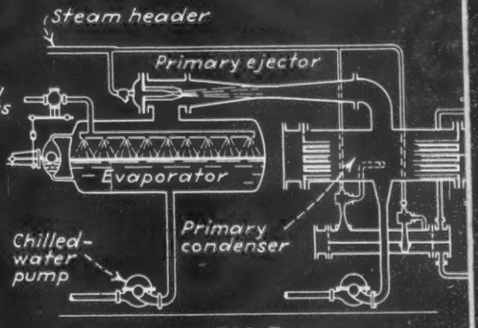


FIG. 3

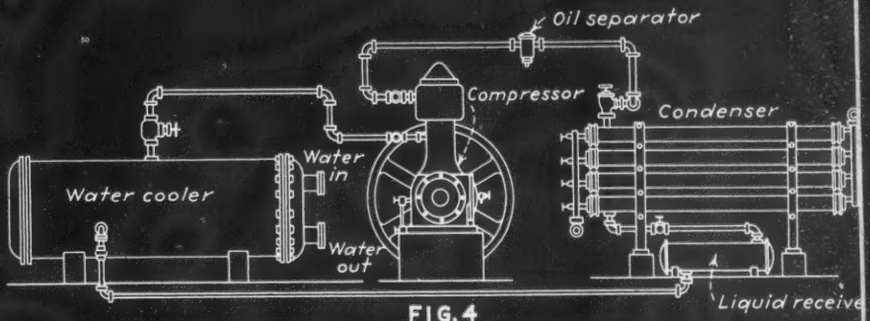


FIG. 4

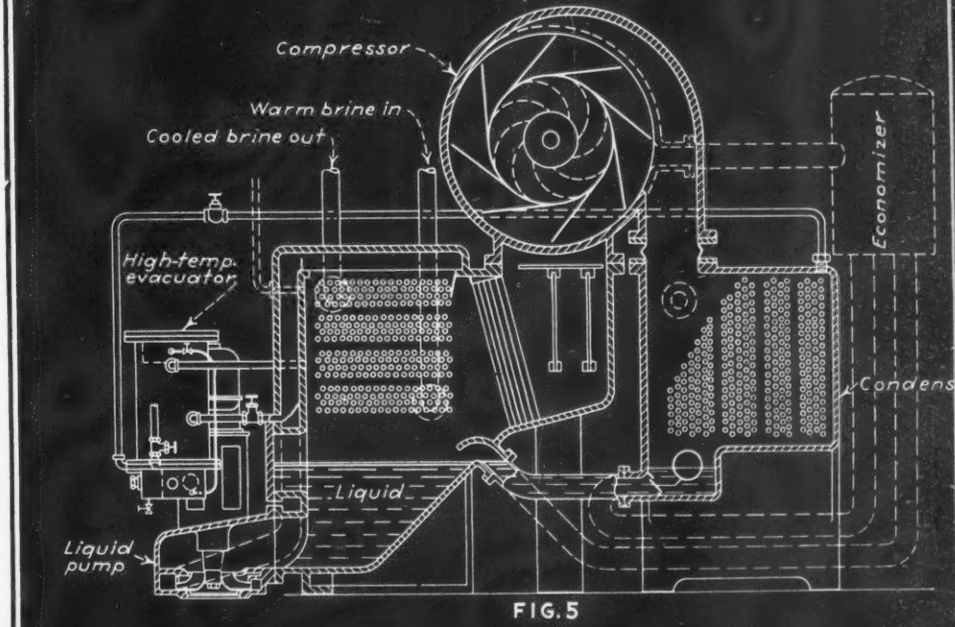


FIG. 5

DELIVERING

Given a supply of conditioned air, how can you get it into a room without neck-chilling drafts, whistles, noise or alternate hot and cool bands? Here is the answer

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WHEN we supply conditioned air to a room, we are merely mixing air at one condition with air at another condition, but the process is not as simple as described in "Mixing," page 189. First of all, heat, both sensible and latent, is being added to the room from many sources. Secondly, the mixing of the colder conditioned air in summer with the hot room air must be done without creating cool drafts while at the same time providing air movement and uniform distribution.

Relatively few rules can be given for the best way to supply air, as each room has its own peculiar characteristics in shape, height of ceiling, location of windows and doors, and heat liberation, all of which should be taken into consideration. Judgment born of experience is needed to obtain a supply system that will give satisfactory results.

Permissible difference in temperature between the air in the room and the air in the duct just behind the supply grille depends upon such factors as inlet velocity, characteristics of the grille, its location and direction given to the supply air. Remember that cold air tends to fall, hence the greater the temperature difference the higher must be the entering velocity to prevent the colder air from falling to the occupied zone before it has had a chance to mix with enough room air to warm it to nearly room temperature. A relatively slight movement of cool air striking the head or shoulders will cause discomfort and complaint. In the occupied zone, air motion should be less than 2 ft. per sec.

Because of these restrictions, conditioned air is not discharged horizontally from supply grilles placed in the occupied zone. They are either in the walls near the ceiling, or in the ceiling with grilles arranged to discharge the air horizontally. Exceptions to this are inlets arranged to discharge nearly vertically (such as used with unit conditioners) and inlets at windows which are made a part of radiator enclosures.

When wall inlets are used, the velocity should not be so high that it carries the conditioned air to the opposite wall, because here a downward draft is created which may catch somebody in the back of the neck. When the distance to the opposite wall is more than 35 to 45 ft., velocities as high as 1,000 to 1,500 f.p.m. can be used, providing the supply grille is correctly designed. As the room becomes smaller, velocity should be decreased or drafts will result.

When low-velocity, non-aspirating inlet grilles are used in a wall close to the ceiling and discharging horizontally a good rule is to limit the temperature difference between supply and room temperatures to $\frac{3}{4}$ deg. for each foot of ceiling height. Thus, if the ceiling is 14 ft. high and the room temperature is to be kept at 78 deg. the supply should be $78 - (\frac{3}{4}\text{x}14) = 67.5$ deg.

With high velocities and aspirating grilles, temperature differences as high as 20 deg. have been used without causing discomfort.

A great variety of supply grilles are available, some simple, others fancy. Those shown are of the less-fancy type engineered to produce specific results. Many grilles are arranged like those illustrated so that the directing vanes can be set at various angles to diffuse the air in plan. One such grille 2 ft. wide with vanes set for maximum diffusion will cover a space 20 ft. wide and 45 ft. long when the velocity is 1,000 f.p.m. Some are provided with adjustable dampers for volume control, thus eliminating the need for duct dampers at the branch from the main supply. When very large spaces are conditioned, ceiling inlets combined with lighting fixtures are frequently used.

In offices, auditoriums and theatres, noise may be an important factor. One source is air issuing from a grille at high velocity. It makes a whistling sound which can be prevented by proper grille design.

In "Mixing," page 189, it was indicated that the ratio of sensible heat load to latent heat load determines the dewpoint of the supply air necessary to maintain a desired room relative humidity. How then is this temperature obtained? Earlier in this article we have shown the factors influencing the entering dry-bulb temperature. Therefore, assume this has been fixed at 68 deg. for a room temperature of 78 deg. and 50% relative humidity. If then we can find one other condition of the supply we can locate its position on the psychrometric chart and read off all the others. It is easy to find the heat that a pound of supply air will gain on entering the room from the formula

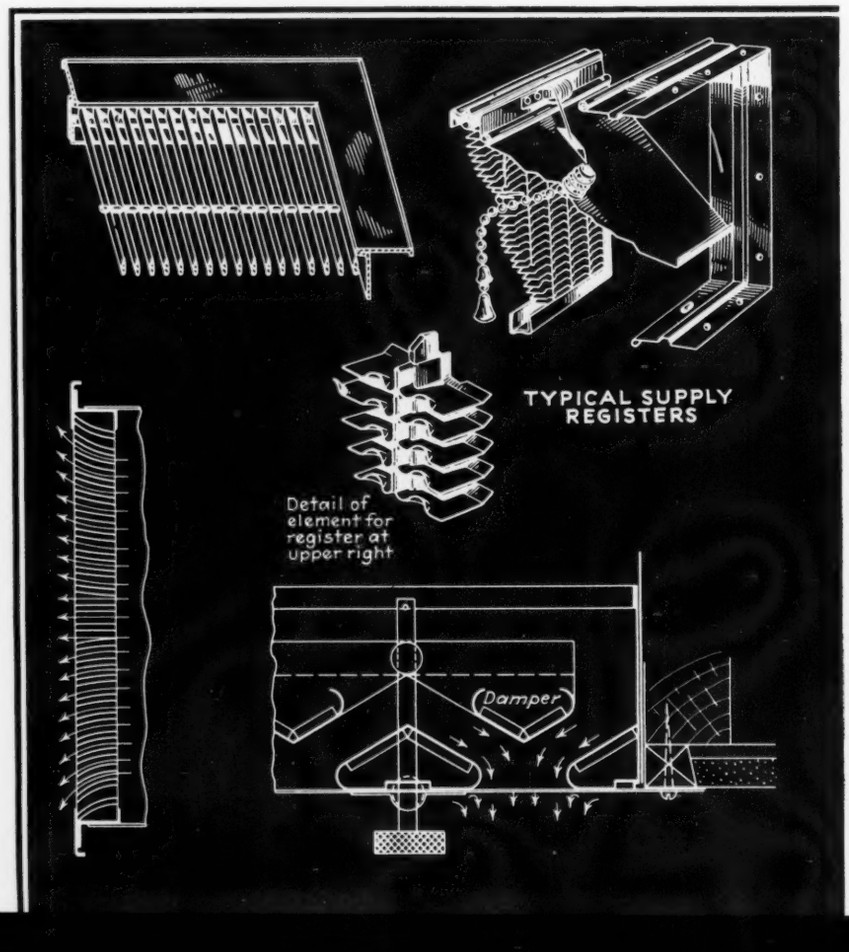
$h = \frac{0.24}{R}\ (t_R - t_s)$ where R is the ratio of sensible heat load to total heat load, t_R is room dry-bulb and t_s is supply-air dry-bulb. If R for the room under consideration is 68.6%,

then $h = \frac{0.24}{0.686}\ (78 - 68) = 3.5$ B.t.u. gained

by each pound of supply. Since the total heat in a pound of room air is 30 B.t.u., the supply air must have a total heat of $30 - 3.5 = 26.5$ B.t.u. This fixes its wet-bulb temperature at 60 deg. and its dewpoint at 55 deg., the conditions given in "Mixing." If we assume the total cooling load for this room has been calculated as 630,000 B.t.u. per hr. (See "Refrigeration," page 190), the quantity of air supplied is found by dividing it by the heat gain per pound or

$\frac{630{,}000}{60\text{x}3.5} = 3{,}000$ lb. per min. This figure

is needed for designing duct work and selecting fans (See "Moving," page 188).



CONTROLLING

Air-conditioning units must be directed in their work to suit changing needs. Unless all elements are properly inter-related, the whole job is a failure

AIR CONDITIONING without control is like a ship without a rudder—it won't do what you want it to do. Successful operation requires steering apparatus, the primary elements being thermostats and humidistats. They are used in the air-conditioning system to control the operation of dampers, steam valves on heating coils, and 3-way valves on the air washer.

Thermostats are sensitive only to the dry-bulb temperature. The sensitive element in most instruments is either a bi-metallic element whose shape is changed because of the difference in the expansion coefficient of the two metals of which it is made, or a bellows containing a volatile liquid. Flat, spiral and curved bi-metallic elements are in use, many with several control points. Sometimes a thermostat with two temperature-sensitive elements is arranged to maintain a predetermined temperature difference, then is called a differential thermostat. Thermostats may also be arranged so that their settings can be remotely changed either by hand or automatically by a pilot thermostat.

Humidistats are sensitive to relative humidity. The sensitive element is hygroscopic and expands as it absorbs moisture and contracts when it dries. Human hair and special paperlike fabric are among the hygroscopic materials used. Other types use two sensitive elements connected through a linkage, one sensitive to dry-bulb temperature, the other kept wet by an atomizer, hence sensitive to wet-bulb temperature.

Combinations of temperature- and humidity-sensitive elements control according to effective temperature. The instrument of this type illustrated shows both elements. The thermostatic element at the left moves the center blade between two contact points as temperature changes occur, and the humidity-sensitive element at right changes the position of the contact points with changes in relative humidity to maintain a constant effective temperature.

These primary instruments do not have sufficient force to exercise direct control, but act as pilot operators for compressed-air or electrical controls. Unit conditioners usually incorporate electrical controls. Central systems, either large or small, may be controlled either electrically or by compressed air, in the latter case requiring tie-in with an existing compressed-air system or installation of a small compressor.

Thermostats are arranged for quick-acting or gradual-acting control. With quick action, the controlled equipment is either wide open or completely closed. Such operation is usually required for steam valves on heating coils to prevent partial heating and wire-drawing of the valve. But with proper equipment design, the gradual-action type may be used. Gradual-operating thermostats or humidistats operate to control the damper or valve in proportion to the variation of temperature or humidity. If the temperature increases slightly above the instrument setting, the damper or valve will change slightly to cause cooler conditions. Such control is necessary for bypass dampers, the 3-way mixing valve on the air washer, and pilot thermostats. Gradual control is obtainable with electric and pneumatic types.

Thermostats may also be arranged for either direct-acting or reverse-acting control. A direct-acting thermostat increases the force applied with increasing temperature. A reverse-acting thermostat increases the force applied as the temperature decreases.

Thermostats and humidistats are placed in the ducts and plenum chambers of the air-conditioning system and in the conditioned rooms.

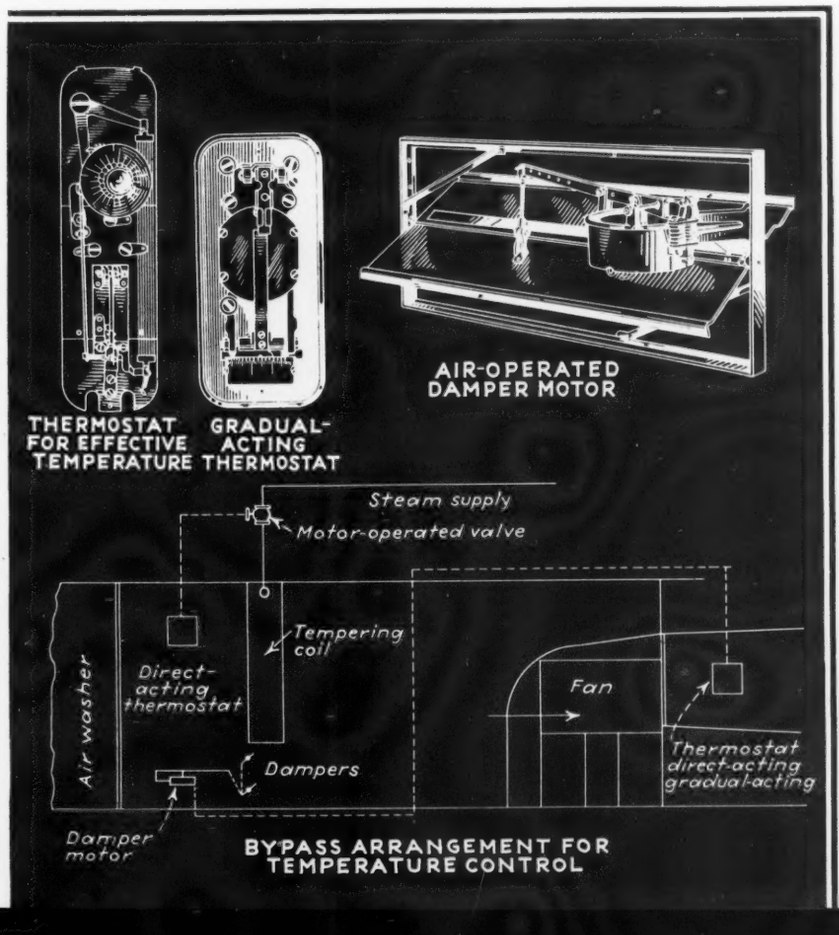
Room thermostats should be placed well in the general circulation of room air and in a position that as nearly as possible represents average conditions. This means on inside walls and away from windows, doors, radiators, elevators or other disturbing influences. Do not place a thermostat where the sun can shine on it. Locate the instrument with consideration for ease of wiring or piping, but not at a sacrifice of control accuracy.

Typical damper motors, quick-operating and gradual-operating valves are illustrated. These may be either reverse or direct acting. A direct-acting valve is normally open and closes as the air pressure or other force increases. A reverse-acting valve normally closed opens with increasing air pressures.

In central conditioning systems, damper motors are required to operate dampers in the fresh-air inlet, vitiated-air outlet, dampers controlling the amount of return air entering the air washer and in the air-washer bypass, and also dampers bypassing tempering and heating coils. Thermostatically controlled valves are required at the preheaters and reheaters if used and a 3-way valve to control the temperature of the air washer when it is supplied with cold water. In addition, various temperature- and pressure-controlled valves are used on the refrigerating system.

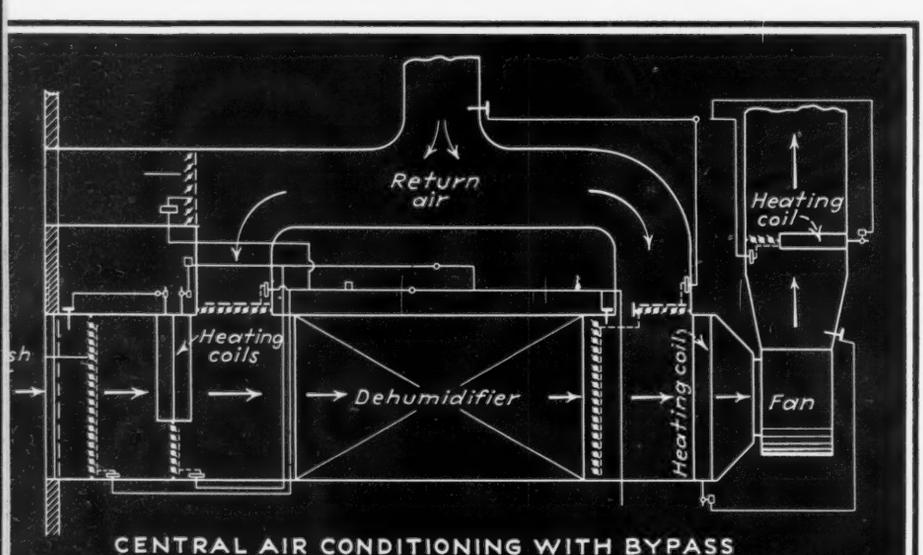
One method of controlling temperature of air being heated by a fin coil is illustrated. When the air temperature drops below the setting of the direct-acting quick-acting thermostat ahead of the heating coil, the steam valve is opened wide. The gradual-acting direct-acting thermostat in the fan discharge controls the damper motor, thus permitting enough air to bypass the heater to satisfy its temperature setting.

"Buttoning Up the Job," page 194, will show how the elements of air conditioning are assembled to form various systems, and how they are controlled.

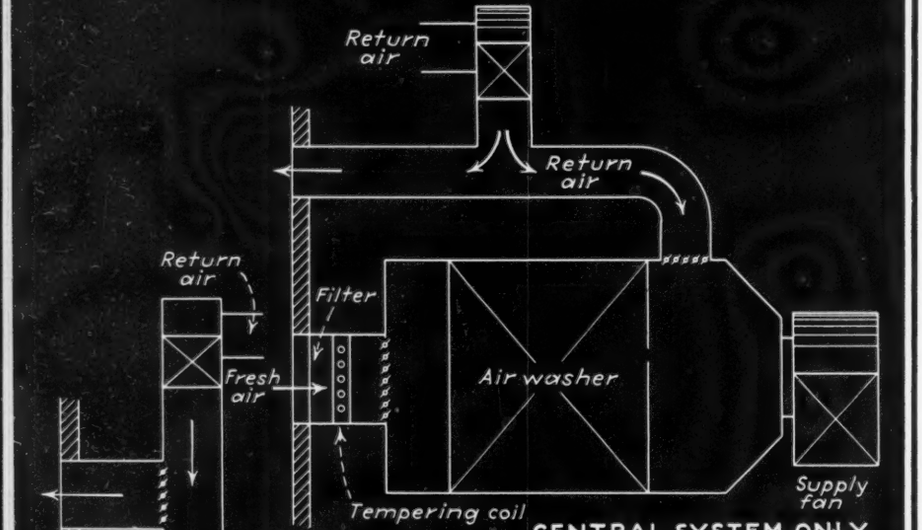


BUTTONING UP THE

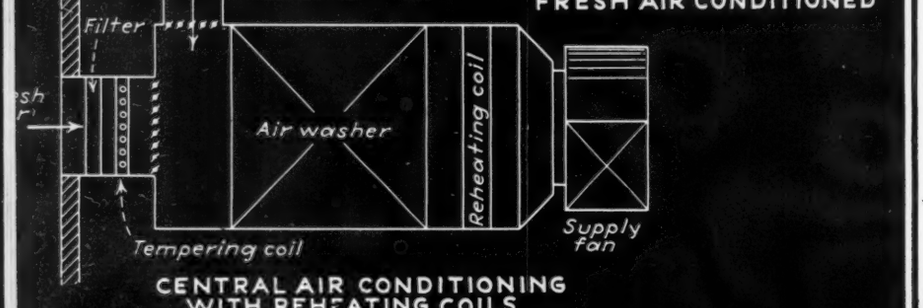
The crossword puzzle called "air conditioning" has been discussed piece by piece in previous articles. Here the pieces are reassembled, but now with the function of each part known



CENTRAL AIR CONDITIONING WITH BYPASS



CENTRAL SYSTEM, ONLY FRESH AIR CONDITIONED



CENTRAL AIR CONDITIONING WITH REHEATING COILS

PREVIOUS articles have discussed the individual functions of cooling, drying, heating, humidifying, filtering, moving and control, together with the equipment necessary for each. In any complete air-conditioning job, all of these functions are performed. This section has discussed them separately, because in many cases complete air conditioning is not necessary and because the functions are individually familiar to power engineers. Let us see now how these separate functions and equipment are put together to form a completed job. It is not our intention here to present finished designs, but to show some of the variations.

First of all, there are two types of installations, those employing unit conditioners and those using central plants. Likewise, unit conditioners may be used with a central refrigerating plant that supplies cold water or liquid refrigerant to them.

The central plant is usually put in in large installations and in new buildings when the necessary ducts to carry the conditioned air can be installed during building construction. Air conditioning for theaters, auditoriums, hotels, complete office buildings, etc., is usually accomplished with central systems.

Unit air conditioners, on the other hand, are economically employed for smaller jobs, particularly when single or isolated rooms in a building are to be conditioned. They make it possible to condition particular rooms or offices open at night without conditioning the entire floor or entire building. They are easier to install in existing buildings because ductwork does not have to be provided—and ducts can become both expensive and difficult when costly interior decorations are involved. On the other hand, electricity, cold-water supply and return steam and drain piping must be provided. Only an air-conditioning engineer can tell you which system will work out to be most economical.

There are many types of unit conditioners, some assembled in pleasing decorative cabinets intended for use in offices, restaurants, small stores and similar places. Others are intended for industrial use or to be placed in an adjoining room, hence are not expensively finished. Many units are designed to provide complete all-year-round conditioning, whereas others provide only for cooling and dehumidifying. Which of these latter types is to be used is largely a matter of how much one wants to spend and whether or not complete conditioning is required.

A few typical units are illustrated. Most commercial units use fin coils for cooling and drying the air, which is delivered vertically by fans in the unit. Some have automatic refrigerating units mounted directly in the cabinet supplying liquid refrigerant to the cooling coils, whereas others are designed to use cooled water or brine as the cooling medium. When winter conditioning is included, humidification is accomplished by

JOB . . .

pans, small atomizing nozzles and moistened fabric, as explained in "Moistening," page 186. These methods do not provide any real control of humidity, but do produce conditions considerably better than are usually present when direct heating alone is used.

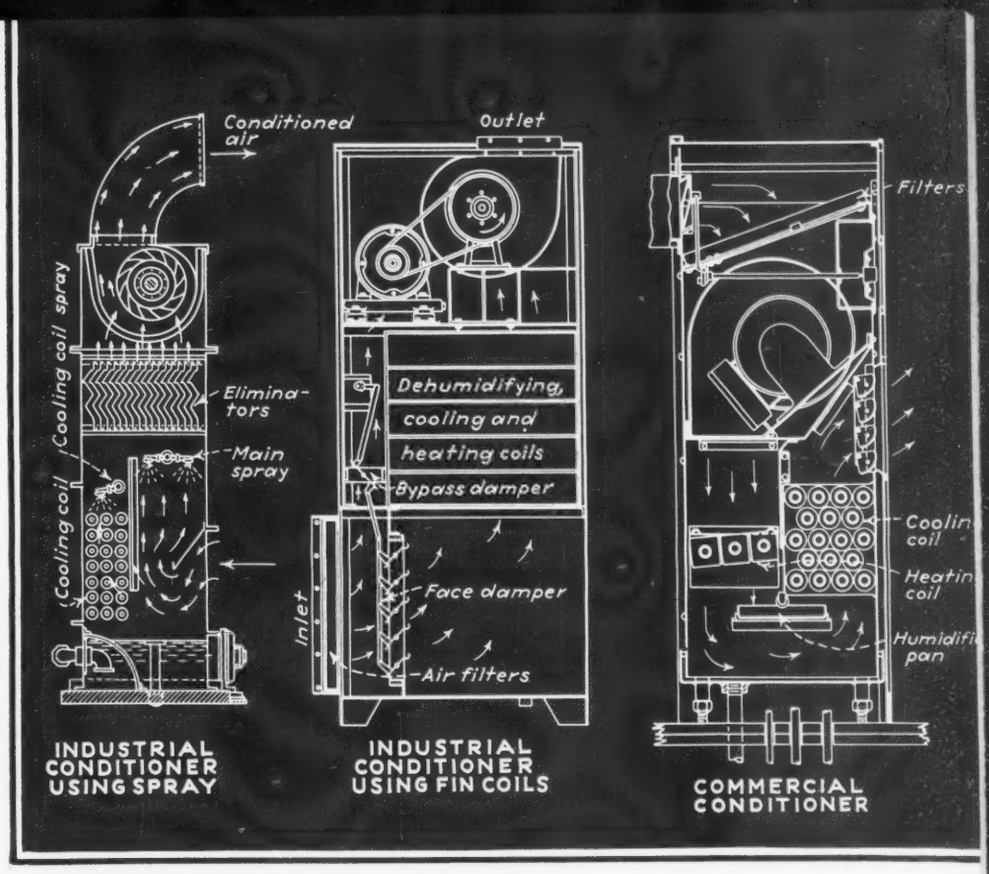
Unit conditioners of the commercial type are generally placed on the floor under windows, or along an outside wall when a window position is not possible. In either case they can be arranged to bring in fresh air.

Industrial types often use spray washers similar to those in central installations. The unit shown with sprays also has water-cooling coils supplied with refrigerant. Temperature of the recirculated spray water is controlled by turning the spray on and off over the cooling coils. These units are made either for ceiling or floor mounting, and generally are of larger capacity.

Filters should be provided at the unit inlet to keep dust and dirt (particularly lint) from getting in and also to keep the air in the room cleaner. Lint on finned cooling and heating coils will quickly decrease their capacity, and dust on heating coils causes odors.

Quiet operation is of paramount importance in units installed in the conditioned space. For this reason, the manufacturer must design his fans with great care and rate them conservatively, then mount them on noise-isolating bases.

Control of unit conditioners may be manual or thermostatic, the simplest method being to shut down the fan when room conditions become too cool in summer or too warm in winter. Other methods employ thermostatically operated dampers that control the proportion of fresh and return air circulated and temperature of the supply air by regulating bypass dampers.



Central Systems

Several diagrammatic arrangements of central systems are illustrated. The difference between them is largely in the way return air is handled and in methods of control.

When the return air is likely to take with it odors that are not removed by air washing or filtering and which are objectionable in the conditioned space, all return air must be exhausted from the building and only fresh air conditioned and delivered. This is comparable to 100% makeup on a heating boiler and is, of course, a heavy cooling load on the refrigerating plant in the summer and a heavy steam load for winter heating. Likewise if no provision is made for recirculation, the cost of precooling for occupation is high.

When odors will be taken out by the air washer, all return air may be recirculated. This, of course, decreases greatly both the cooling and heating loads. In summer, however, it is necessary to use steam to raise the temperature of the dehumidified air as it leaves the air washer in order to raise its temperature to a point where it can be introduced into the room without discomfort.

To avoid this use of steam during the summer, return air may be introduced after the air washer in sufficient quantity to warm dehumidified fresh air taken through the air washer. Return air not needed for this purpose is exhausted from the system. But this increases the amount of fresh air brought in, therefore increases the cooling load on the refrigerating plant. This method can be used economically when cooling requirements are directly proportional to the outside air required for ventilation.

If instead of exhausting all return air not used for reheating we recirculate it with the fresh air back through the air washer, the fresh air introduced in hot weather can be kept at a minimum and the cooling load decreased. This "bypass system," as it is called, is most economical with respect to refrigeration. Sometimes instead of providing a bypass as shown, arrangements are made in the air washer to shut off certain nozzles at the top so that the air passing through this system of the washer is not cooled. This is similar in effect to bypassing.

Another method of bypassing used in conditioning buildings several stories high is to deliver cold conditioned air through a main vertical duct and at each floor provide a branch connection to a plenum chamber. In this chamber is a fan which distributes conditioned air to that floor. An inlet from the floor area to the plenum chamber makes it possible for the fan to draw a mixture of return air and untempered conditioned air. Dampering in the return inlet and conditioned-air outlet permits regulating the proportion of return and conditioned air to give the desired supply-air temperature. This arrangement is very flexible and permits adjustment for different heat loads that may occur on various floors. It, of course, requires a larger number of fans, although total fan capacity would be only slightly more than that with the usual bypass system.

The diagrams all show both fresh-air inlet and return-air exhaust or relief connections. From the viewpoint of economy, the less fresh air taken in and the more return air used the lower will be the summer refrigeration load, likewise the lower will be the winter heating load. Two factors determine the practical limit below which the amount of fresh air used cannot be cut. Most important is the necessity of providing sufficient fresh air to reduce room odors due to occupancy. This is particularly important in theaters, stores, office buildings, etc. A minimum of about 10 c.f.m. of fresh air per person is required to keep body odor down to a satisfactory level. Some installations use as much as 25 to 30 c.f.m., as required by local health ordinances. Likewise, enough fresh air must be taken in to make up for loss of air due to filtration from the building and to maintain a positive pressure. Filtration loss is generally equal to from ½ to 2 changes of air per hour. It is very uneconomical and difficult to maintain correct air conditions in a structure that leaks more than this.

At certain times between seasons the outside air condition is just right for comfort and health. Or if it isn't much too warm, advantage may be taken of some evaporative cooling. The system should be arranged so it can take advantage of these outdoor conditions. A large enough fresh-air inlet must be provided, and of course, a similarly proportioned return-air outlet or relief connection. With these considerations in mind, fresh-air inlets and relief connections are each provided with two sets of dampers. One set should be large enough so that they alone can take care of the minimum of fresh-air and relief requirements in winter and summer. The other set is closed during these

seasons. Between seasons, when all dampers are open, they must be capable of handling at velocities of about 1,000 f.p.m. the maximum fresh- and relief-air requirements. These dampers may be either manually or thermostatically operated.

The quantities of air passing through different parts of the air-conditioning equipment in per cent of the volume handled by the supply fan is shown in the table. It is based on inside conditions of 80 deg. with 50% relative humidity and a 15 deg. differential between supply and room temperature. The percentages given cannot be taken to apply to your particular job but are intended to indicate approximate relative proportions of an average bypass central conditioning system.

TYPICAL PER CENT AIR QUANTITIES

	Fresh Air 1,000 f.p.m.	Dehum. Air 600 f.p.m.	Bypass Air 600 f.p.m.	Return Air 1,000 f.p.m.	Relief Air 1,000 f.p.m.
Summer....	Min. 16% Capacity	Med. 46%	Med. 54%	Max. 30%	Min. 6%
Winter.....	Min. 16% Capacity	Min. 23%	Max. 77%	Min. 7%	Min. 6%
Spring & Fall.....	Max. 56% Capacity	Max. 56%	Med. 44%	None	Max. 46%

Note that maximum fresh air is required in between seasons. Return-air connections, ducts, dampers, etc., are designed for summer conditions; the bypass connection will carry its maximum volume in the winter; the dehumidifier handles more air during Spring and Fall seasons, likewise maximum exhaust occurs then.

In "Moving," page 188, the importance of balancing pressure conditions in the fresh- and return-air circuits was mentioned. The system should be designed so that the resistance to the flow of return air through the air washer is equal to the resistance to its flow around or bypassing the washer, otherwise control difficulties will likely result. Likewise, care should be taken to prevent fresh air from bypassing the air washer, although usually there is sufficient resistance in the return side to prevent this.

"Control," page 193, discussed the various elements used, but did not show how they were assembled to make a coordinated control system. On page 30 of the January number of *Power* a diagram of a typical air-operated control system was shown and explained. Below is an electrical system.

With an electrical control system, the controls operate thus:

In winter, the temperature controller at the intake of the preheater is set at some temperature control point above freezing and regulates the controlling motor, which in turn determines the relative positions of the outdoor and return-air dampers so air is delivered to the conditioner at this predetermined temperature. A manual switch provides for setting the dampers at any desired position in summer, also in winter if preferred.

The winter dewpoint controller regulates the flow of steam to the preheater through operation of the motor-controlled motorized valve to deliver air from the sprays at a predetermined winter dewpoint temperature. In winter, the motorized 3-way mixing valve will be automatically placed in the position which provides all recirculated water to the sprays, using no cold water. The summer dewpoint controller is set at a higher temperature control point than the winter dewpoint controller. This therefore, provides for automatic change-over as load changes from heating to cooling, or cooling to heating. The summer dewpoint controller regulates the proportions of recirculated and cold water to the sprays through operation of the motorized 3-way mixing valve so that air is delivered from the sprays at the predetermined summer dewpoint temperature.

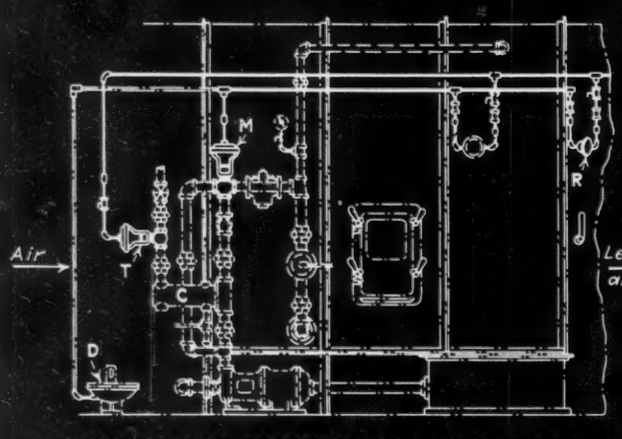
Positions of the reheater face and bypass dampers are regulated by the temperature controller in the return air, delivering more or less air through the reheater coils as heat requirements increase or decrease. Steam flow to the reheater coil is modulated by a motorized valve operated by a dual-control switch on the controlling motor operating the face and bypass dampers. This combination provides an accurate and reliable control of return-air temperature, and the temperature controller in the delivered air prevents air at this point from falling below a predetermined temperature.

All preceding articles have dealt with the air-conditioning problem in general and with each element of air conditioning in particular. In this article, we have endeavored to button the parts together into a system, be it a small unit or a complicated central plant involving ducts and conditioned air distribution and control. Then we have gone on to give pointers on system operation, for no air-conditioning system is worthy of the name unless in addition to being a proper installation it is a properly operated one.

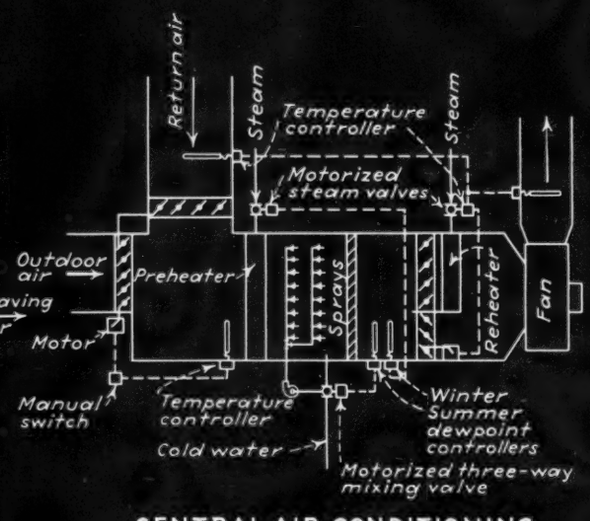
You have probably become convinced of one thing as you read through this discussion—namely, that air conditioning is just a new name for a rearrangement of a number of types of familiar equipment. The pumps, the equipment and the individual processes, with the possible exception of humidifying and dehumidifying, are all "old stuff." The differences arise in controls on a different basis, and in the necessity for figuring things out in a different way.

All we could hope to do here was to point out fundamentals and to give some indication of how capacities and relative sizes are worked out. The details vary with the installation, and must be worked out for that installation, a problem for the specialized air-conditioning expert, not for the operator. But once the system is in—or even when it is being considered—the operating engineer must be familiar with the equipment and processes involved, for after all, it is the engineer's responsibility to keep it in operation.

Air conditioning, just like any other power-service problem, is not a matter of simply installing a system and then forgetting about it. It requires careful, consistent and enlightened operation, otherwise it cannot and will not deliver all that is expected of it. In addition to understanding the system, you must operate and maintain it properly. You should no more think of installing air conditioning and then letting it run itself than you would of installing a new boiler, then going away and letting it run itself without even an occasional check-up. Data on operation and maintenance is beyond the scope of this particular section, but is given in *Power's* articles on air conditioning. Watch for them and study them, for they can give you the pointers that combine with this summary to make you deserving of the title, "Air-conditioned Engineer."



PIPING AND CONTROL AT AIR WASHER



CENTRAL AIR-CONDITIONING ELECTRIC CONTROL

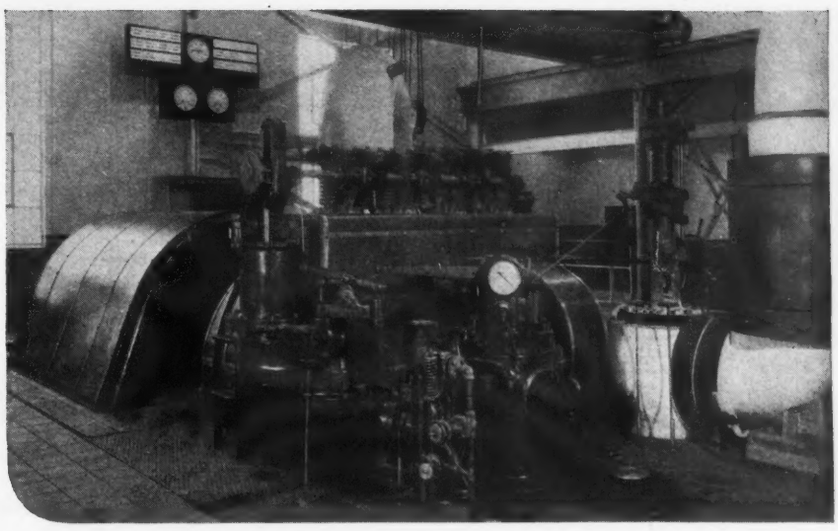


Fig. 1 — This 6,000-kw. turbine-generator operates with steam at 650-lb. and 750 deg. F. and exhausts into the low-pressure header at 210 lb. and 530 deg.

"TOP" Cuts Coal Rate 42%

By installing a 660-lb., 6,000-kw. "top" on a low-pressure plant, Rochester Gas & Electric Corp., reduced coal rate on a 21,000-kw. load from 1.9 to 1.1 lb. per kw.-hr. This is the first step in a progressive modernization program.

ON THE power system of the Rochester Gas & Electric Corp., Rochester, N. Y., there are six steam-electric generating plants, with capacities ranging from 750 to 62,500 kw. Only the latter, known as No. 3, operates condensing. All the others exhaust into the company's extensive district-heating system, and therefore, heating- and process-steam requirements of this system determine their power output.

When in 1934 it became evident that more off-heating season power-generating capacity would soon be necessary, consideration was given to several possibilities. Of these, modernizing No. 3 plant with a high-pressure "top" proved to be the most economical. This plan would not only give maximum capacity for a given investment but also produce a kilowatt-hour at a lower cost than any other. For the present it saves all the investment in the old plant and makes its efficiency comparable with that of a modern station. The plan allows progressive modernization of the plant as new capacity is required without interfering with operation.

Plant No. 3 comprised 22 boilers, twelve having 8,700 sq.ft. and ten 6,000 sq.ft., of water-heating surface. Twenty are stoker- and two pulverized-coal-fired, all supplying steam at 200 lb. gage. Some of the boilers are more than 25 yr. old. Generating units include one 15,000-kw., four 10,000-kw. and one 7,500-kw. turbines.

Space was available at one end of the plant to build an extension to house two high-pressure units and use one of the present stacks. The first unit has been in operation for about four months. This unit comprises a boiler with a maximum continuous rating of 250,000 lb. of steam per hr. at 660 lb. and 750 deg. F. total temperature and a 6,000-kw. turbine-generator exhausting at 210 lb. and 530 deg. F. total temperature at full load.

The size of this unit was determined by the 15,000-kw. low-pressure turbine. Although the high-pressure turbine exhausts through a desuper-heater into the low-pressure steam main, it can serve as a "top" on the 15,000-kw. machine and the two operate as a 21,000-kw., 650-lb., 750-deg. condensing unit.

The second high-pressure unit will have a capacity of 7,500 kw., this being sufficient to act as a "top" for two 10,000-kw., low-pressure machines, the combination operating as a 27,500-kw. condensing unit. Future extensions will be made by replacing old boilers and turbines with high-pressure condensing units, as load increases require, until the whole plant is modernized.

The new boiler, a cross-section of which is shown in Fig. 2, is of the 4-drum, bent-tube type, with a maximum continuous rating of 250,000 lb. of steam per hr. All drums are fusion-welded and X-rayed to insure proper fusion. A fifth drum for steam washing, 48 in. diameter and 23 ft. 7 in. long, connects with the upper rear steam drum by 34 3½-in. steam tubes, and in addition has six 3¼-in. feedwater tubes. The washer is designed to handle the maximum rating of the boiler when its water contains 3,000 parts of concentrates per million and deliver steam containing not more than 5 p.p.m.

The superheater comprises 24 two-loop semi-radiant elements, having 1,330 sq.ft. effective heating surface in lanes of the first boiler-tube bank. Installed behind this bank are 53 convection superheater elements with 3,120 sq.ft. of effective heating surface. Superheat in steam to the turbine is not controlled, but its exhaust is desuperheated to maintain 530 deg. automatically when entering the 200-lb. header.

A separate economizer is provided, but no air preheater, although both were considered. Either or both could have been used with about equal economy, consequently the more simple arrangement of one or the other

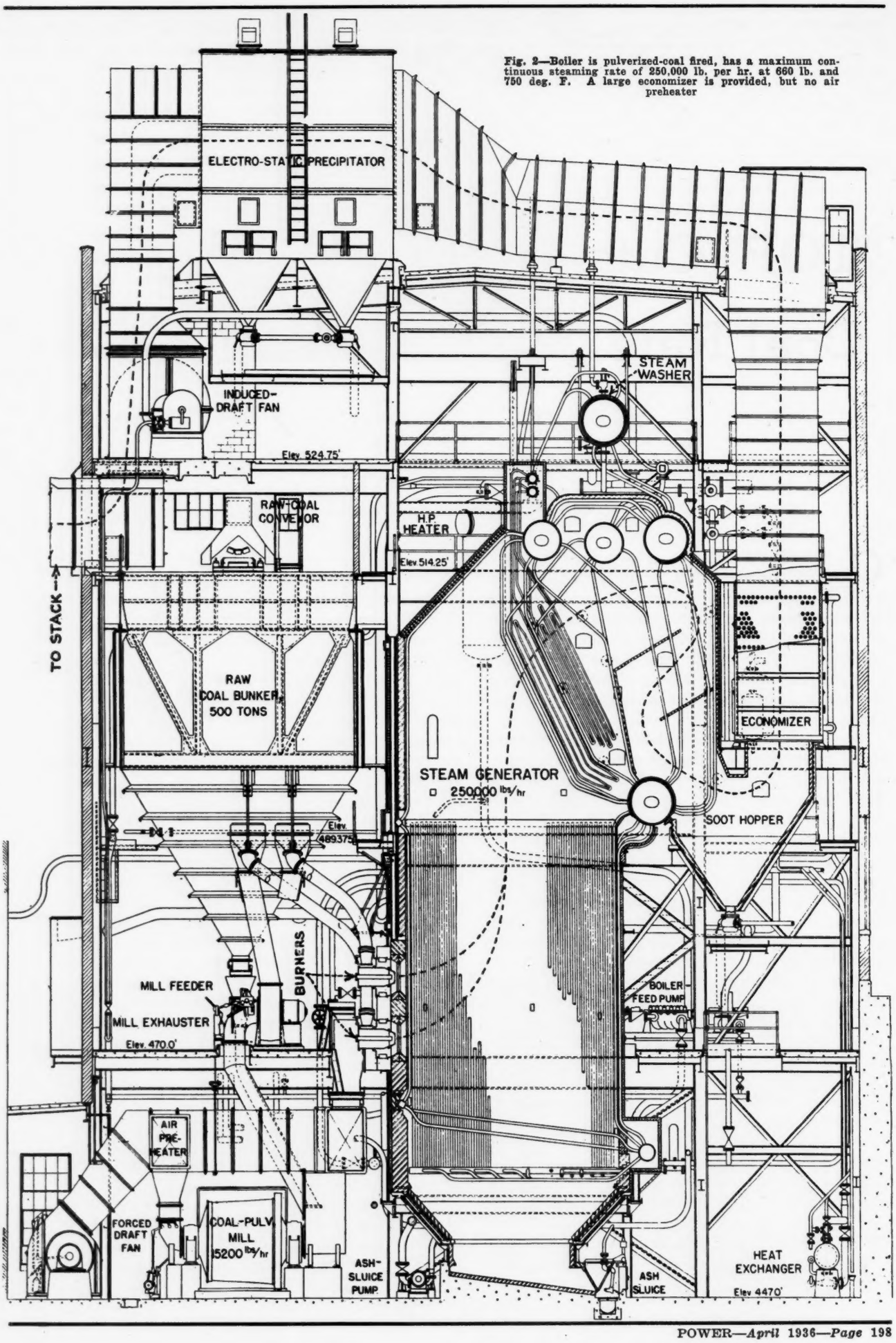
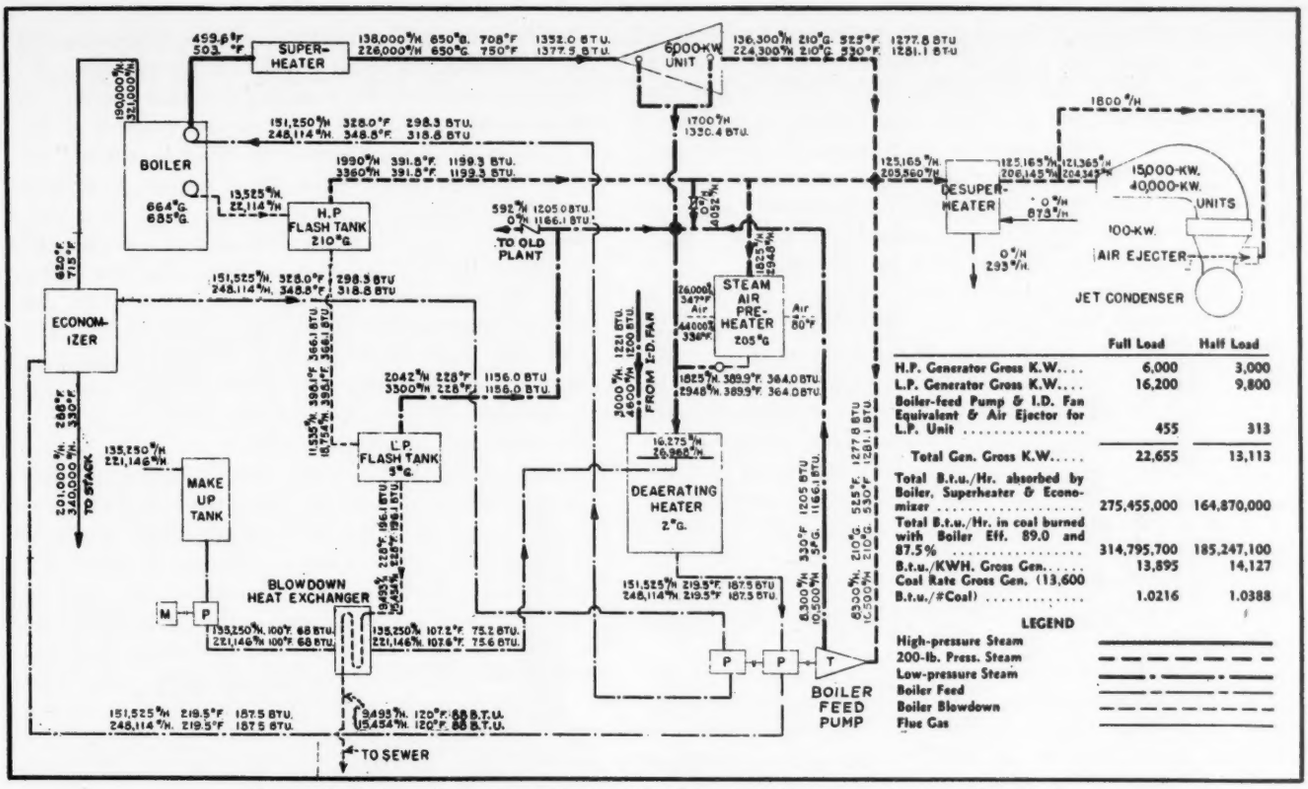


Fig. 2—Boiler is pulverized-coal fired, has a maximum continuous steaming rate of 250,000 lb. per hr. at 660 lb. and 750 deg. F. A large economizer is provided, but no air preheater



	Full Load	Half Load
H.P. Generator Gross K.W.	6,000	3,000
L.P. Generator Gross K.W.	16,200	9,800
Boiler-feed Pump & I.D. Fan Equivalent & Air Ejector for L.P. Unit	455	313
Total Gen. Gross K.W.	22,655	13,113
Total B.t.u./Hr. absorbed by Boiler, Superheater & Economizer	275,455,000	164,870,000
Total B.t.u./Hr. in coal burned with Boiler Eff. 89.0 and 87.5%	314,795,700	185,247,100
B.t.u./KWH. Gross Gen.	13,895	14,127
Coal Rate Gross Gen. (13,600 B.t.u./#Coal)	1.0216	1.0388

LEGEND

High-pressure Steam
200-lb. Press. Steam
Low-pressure Steam
Boiler Feed
Boiler Blowdown
Flue Gas

Fig. 3—Heat-balance diagram at one-half and full load for high-pressure "top" on 200-lb. plant

PRINCIPAL EQUIPMENT FOR NEW UNIT

Rochester Gas & Electric Corp.

Boiler and water walls.....Combustion Engineering Co.
Boiler, heating surface, 15,300 sq.ft.; water walls, 3,990 sq.ft.; max. continuous steaming cap., 250,000 lb. per hr.; working pressure, 660 lb.g.; total steam temp., 750 deg. F.; furnace volume, 13,720 cu.ft.; max. B.t.u. liberated per cu.ft. per hr., 20,000.
Economizer, 20,808 sq.ft. .....Foster Wheeler Corp.
Superheater, 4,450 sq.ft. .....Superheater Co.
Steam washer, cap. 250,000 lb. per hr.
Combustion Engineering Co.
Boiler and furnace setting .....Combustion Engineering Co.
Furnace walls above water wall, DeWolf type of construction. Subcontractor for furnace walls.
Wm. Summerhays' Sons Corp.
Furnace refractories .....Harbison-Walker Co.
Boiler heat insulation .....Smith-Murray, Inc.
Boiler ducts and breechings .....Connery & Co.
Structural-steel contractor .....A. W. Hopeman & Sons Co.

Combustion Equipment.

Pulverized-coal burners, 4, arranged 2 high by 2 wide, cap. each, 7,600 lb. per hr.
Combustion Engineering Co.
Coal pulverizer, 2 ball mills, cap. each, 15,200 lb. per hr. .....Foster Wheeler Corp.
Pulverizers driven by 150-hp. 870-r.p.m. Westinghouse squirrel-cage motors through Bethlehem snub couplings and Falk gears.
Mill exhausters, 2 .....Foster Wheeler Corp.
Driven by 75-hp. Westinghouse squirrel-cage motors
Coal feeders, 2, vibrating type .....Jeffrey Mfg. Co.
Forced-draft fan, 69,000 c.f.m., 4.5 in. static pressure, adjustable-Vortex type .....Clarage Fan Co.
Driven by 75-hp. Westinghouse squirrel-cage motor through Bartlett-Hayward Co., Fast flexible coupling.
Induced-draft fan, double-width, double inlet..Clarage Fan Co. Driven by 200-hp. 3,645-r.p.m. Allis-Chalmers steam turbine, through Falk herringbone reduction gears and Bartlett Hayward Co., Fast flexible coupling. Speed adjusted by Bailey combustion control.
Steam air-heaters, 2; cap. each, 30,000 lb. air per hr. 80 to 347 deg. F., Aerofin type ....American Blower Corp.

Coal and Ash Handling.

Coal-handling equipment, apron feeder, belt and bucket conveyor, belt conveyor and tripper
Robins Conveying Belt Co.
Motor drives on coal-handling equipment
Westinghouse Elec. & Mfg. Co.
Motor control on coal-handling equipment
I-T-E Circuit Breaker Co.
Hammermill crusher .....Pennsylvania Crusher Co.
Crusher driven by 40-hp. Westinghouse motor through Bethlehem snub coupling.
Ash-handling equipment, Hydrojet on furnace bottom and Hydrovac on flyash system for economizer and electrical precipitator .....Allen-Sherman-Hoff Co.
Electrical soot precipitator, Cottrell type.....Research Corp.
Soot blowers, boiler 16, economizer 16
Diamond Power Specialty Co.

Control and Valves.

Water columns, 2.....Diamond Power Specialty Co.
Water-level indicator .....Diamond Power Specialty Co.
Floor level water column .....Diamond Power Specialty Co.
Water-level recorder .....Bailey Meter Co.
Feedwater regulator .....Bailey Meter Co.
Automatic combustion control .....Bailey Meter Co.
Safety valves .....Consolidated Ashcroft Hancock Co.
Blow-down valves .....Cochrane Corp.
Forged-steel needle valves.....Edwards Valve & Mfg. Co.
Non-return valves .. ..Edwards Valve & Mfg. Co.
Stop and check valves in feed line.....Lunkenheimer Co.
High-pressure valves .....Lunkenheimer Co.
Medium-pressure valves .....Reading Pratt & Cady Co.
Reducing valves.....Bailey Motor Co.
Electric valve operators, Limitorque
Philadelphia Gear Works
Piping .....W. K. Mitchell & Co., Inc.

Feedwater System.

Boiler feed pumps, 2, each comprising a primary and secondary pump in series. Primary pump, 642-ft. head, secondary pump 730-g.p.m., 1,485-head
Allis-Chalmers Mfg. Co.
Feed-pump drive, one 450-hp., 3,450-r.p.m. turbine
Allis Chalmers Mfg. Co.
Feed-pump drive, one 450-hp., 3,450-r.p.m. turbine
Moore Steam Turbine Corp.
Pump speed-regulating valves .....Bailey Meter Co.
Make-up water pumps, 2 .....Worthington Pump & Mach. Co.
Driven by 50-hp. Westinghouse motors.
Feedwater purification equipment .....Cochrane Corp.
Feedwater deaerating heater .....Cochrane Corp.
Continuous-blowdown equipment .....Cochrane Corp.

Meters.

Boiler-meter and control board .....Bailey Meter Co.
Turbine-meter and control board .....Bailey Meter Co.
Boiler meter .....Bailey Meter Co.
Steam-flow meter .....Bailey Meter Co.
Feedwater level recorder .....Bailey Meter Co.
Feedwater flow meter .....Bailey Meter Co.
Pressure gages, indicating .....Bailey Meter Co.
Pressure gages, recording .....Bailey Meter Co.
Thermometer, ...Taylor Instruments Companies
Temperature recorders .....Taylor Instruments Companies
Draft gages .....Bailey Meter Co.
CO_2 recorder .....Hays Corporation
Smoke-density recorder .....Bailey Meter Co.

Turbine Room.

Turbine-generator, one non-condensing 6,000-kw., 0.80-p.f., 3-phase, 60-cy., 11,500-v., 3,600-r.p.m., with direct-connected exciter.....General Electric Co.
Steam conditions 650 lb. 750 deg. F. at throttle, exhaust 210 lb. 535 deg. F. at full load.
Desuperheater on turbine exhaust .....Blaw Knox Co.
Desuperheater regulator .....Bailey Meter Co.
Generator air cooler .....General Electric Co.
Air-cooler water pump ....Worthington Pump & Mach. Corp.
Rotary strainer on house-service water.....Andale Co.
Oil cooler .....General Electric Co.
Oil purifier .....Sharples Specialty Co.
Station transformers ..... Allis Chalmers Mfg. Co.
Station lighting transformers .....General Electric Co.
Motor-generator, 5 kw., 125 volts .....Electric Products Co.
Generator oil circuit breakers .....General Electric Co.
Generator switchboard .....General Electric Co.
House switchboard .....I-T-E Circuit Breaker Co.
High-voltage cable ..General Electric Co. and Safety Cable Co.
Station auxiliary and lighting conductors
Kerite Insulated Wire Co. and Rockbestos Products Corp.
Electric elevator .....Graves Elevator Co.
Travelling crane, 15-ton ..Shaw-Box Crane & Hoist Co., Inc.

was preferable. If a large air heater had been selected, it would have given air temperatures of approximately 550 deg. F., considered undesirable from an operating standpoint. An air heater alone would require heating feedwater with steam that could be used for power generation. An economizer was therefore selected of sufficient size to raise the feedwater temperature from about 212 to 350 deg. F. during normal operation and reduce the gas temperature to about 330 deg. F.

A furnace of 13,720 cu.ft. volume is provided. At maximum boiler rating, heat liberation of 20,000 B.t.u. per cu.ft. per hr. obtains. Water walls on all four sides of the furnace extend up to an elevation in line with the mud-drum bottom. Above the water walls, on the sides and front, the furnace walls are a DeWolf type of suspended refractory construction supported on structural members. Riser tubes from the water-wall header are between the vertical steel members of the DeWolf construction. From the top of the burners down, the front wall is 18 in. thick, of first-class firebrick. All walls are insulated with 3 in. of Rockwool and incased in No. 12 gage steel.

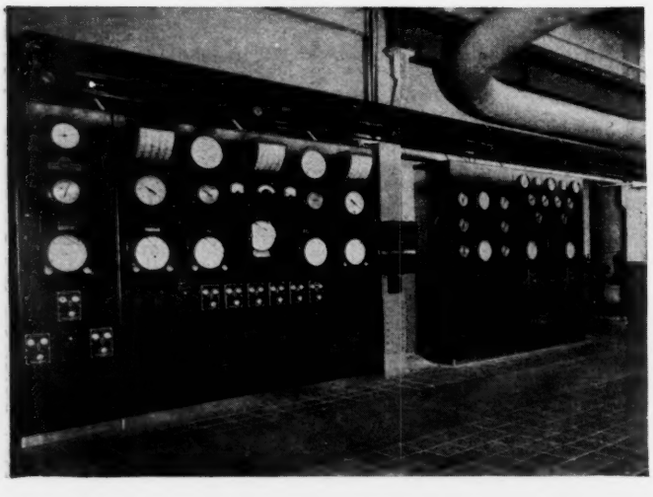
At the bottom of the furnace a slag screen is provided through which ash drops to a refractory-lined hopper. Water from the generator air coolers flows over the surface of this hopper to keep it cool and to disintegrate ash, which is carried away by a Hydrojet sluicing system.

Combustion equipment includes a squirrel-cage motor driven, Vortex-controlled, forced-draft fan, two steam primary-air preheaters; two ball-mill coal pulverizers; two vibrating-type coal feeders, two mill exhausters, four burners, and a steam-turbine driven, induced-draft fan all regulated by an automatic combustion-control system to maintain the correct air-flow steam-flow relation. Only the primary air going to the mills for drying the coal is preheated.

Coal is fed into one end of the mills from the raw-coal bunker by the feeders. Air from the forced-draft duct is taken through the heaters and its temperature raised and thermostatically controlled to give an outlet temperature on the mills of 150 deg. F., which requires preheating to about 350 deg. F. Drawn from the mills by the exhausters, the coal-and-air mixture at 150 deg. is delivered to the burners, where it mixes with the secondary air from the forced-draft fan. Gas flow from the furnace through the boiler, economizer, electrical precipitator, induced-draft fan and to the stack is indicated.

Pulverized-coal equipment is essentially two duplicate unit systems, each with two burners. In the top of the duct from the mill exhauster, a splitter divides the coal-and-air stream, each half going to a burner. No provision has been made for operating less than two burners, as operating conditions will not require very low ratings. Fly ash in the flue gas is removed by an electrostatic precipitator, comprising two units of eleven ducts each, with electrodes of the rod-curtain type. Dust is collected on the rods, and periodically they are struck mechanically to deposit the dust into hoppers below the precipitator.

Fig. 4—Controls for the high-pressure boiler and turbine are centralized on these two meter and control boards



In the old plant, the turbines exhaust to jet condensers, consequently 100% make-up water has to be provided. These condensers were installed a good many years ago and appeared best suited to water conditions at that time. When new condensing units are installed, they will have surface condensers.

River water used for boiler feed is turbid and hard. To condition this water for boiler use it is first heated to about 100 deg. F and given a preliminary treatment in the make-up tank. Then it is treated by a hot lime-soda process to throw down the solids, deaerated and filtered through magnetite ore. In this process the water is heated to about 220 deg. F. A continuous-blowdown system maintains boiler concentrates below a safe value.

Two boiler-feed pumps, each comprising a primary and a secondary pump in series, are turbine driven. Feed water is taken from the deaerating heater by the primary pump and discharged through the economizer at about 250 lb. and then returns to the secondary pump which sends it into the high-pressure boiler, as indicated on the heat-balance diagram, Fig. 3. This diagram gives operating conditions at full and half load, full load being based on a total load on the high- and low-pressure units of 22,200 gross kilowatts.

Steam Turbine

The steam turbine is a 7-stage impulse-type rated at 6,000 kw. with 650-lb., 750-deg. steam at the throttle and exhausting against 210 lb. back-pressure. Under these conditions the exhaust will have a total temperature of 530 deg. F. The turbine has seven governor valves, six of which when open will admit sufficient steam for 6,000 kw. Seven valves in service permit generating 7,000 kw. The generator is designed for 11,500 volts, 3 phase, 60 cycles and is cooled by air recirculated through coolers. Raw river water pumped through these coolers is used, as previously mentioned, to wet the surfaces of the ash hopper below the boiler furnace.

The new unit has been in service since the first of the year, and for the last ten weeks has been practically in continuous operation under full load 24 hr. per day. Opportunity has been had to obtain a fairly good check on efficiency of combined operation of the high- and low-pressure machines. Based on a 21,000-kw. load on the old plant, the best coal rate was 1.9 lb. of 13,600-B.t.u. coal. With the same load, but 6,000 kw. carried by the high-pressure unit, the coal rate is 1.1 lb., a reduction of 42%. The new unit is equipped with a very complete automatic combustion-control and metering system, which will be the subject of another article.

Design of the high-pressure section of the plant was worked out by the E. M. Gilbert Engineering Corp. in cooperation with the engineering and operating departments of the Rochester Gas & Electric Corp. Sheppard T. Powell served as consulting chemist on feedwater.

CITY ADDS 1,225-HP. DIESEL

New Lafayette, La. unit to carry base load, increasing capacity to 3,625 hp. in diesels

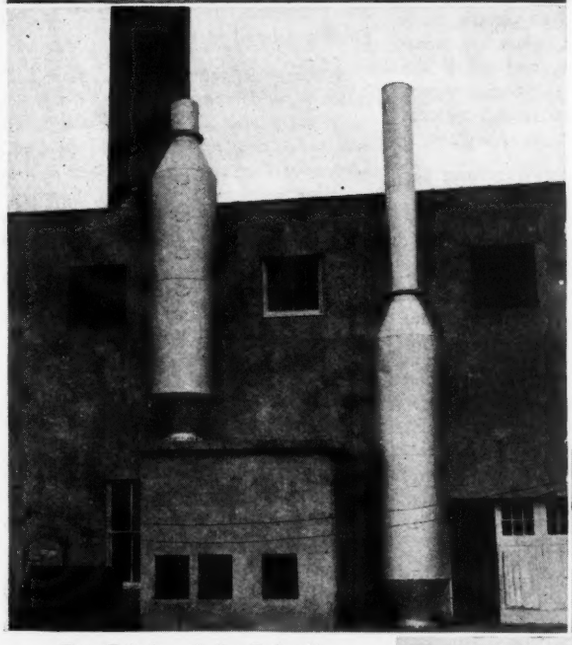
By Helmer N. Anderson
Manager, Fairbanks, Morse & Co.
New Orleans, La.

LAFAYETTE, a Louisiana city of 15,800, has added a base-load 1,225-hp., pump-scavenging, 2-cycle, diesel-electric unit to its 2,400-hp., 4-unit, diesel plant. Tests to indicate whether or not the engine ran quietly and without vibration were made by connecting it directly to city load. Power factor varied slightly with time of day and light and power load, but an 8-hr. full-load test showed 857-kw. output at 12.85 kw.-hr. per gal. of 4.62-cent fuel, giving the low fuel cost of 3.6 cents per kw.-hr. At ¾ load (650 kw. average) for 2 hr., fuel cost increased to 3.7 mills and the engine produced 12.6 kw.-hr. per gal. At half load (435 kw.) the figures were 4.0 mills and 11.4 kw.-hr. per gal. This includes all exciter losses, power losses for the scavenging pump, built-in lubricating-oil pumps, etc. Engine, exhaust, and air intake were quiet and free of vibration at all loads.

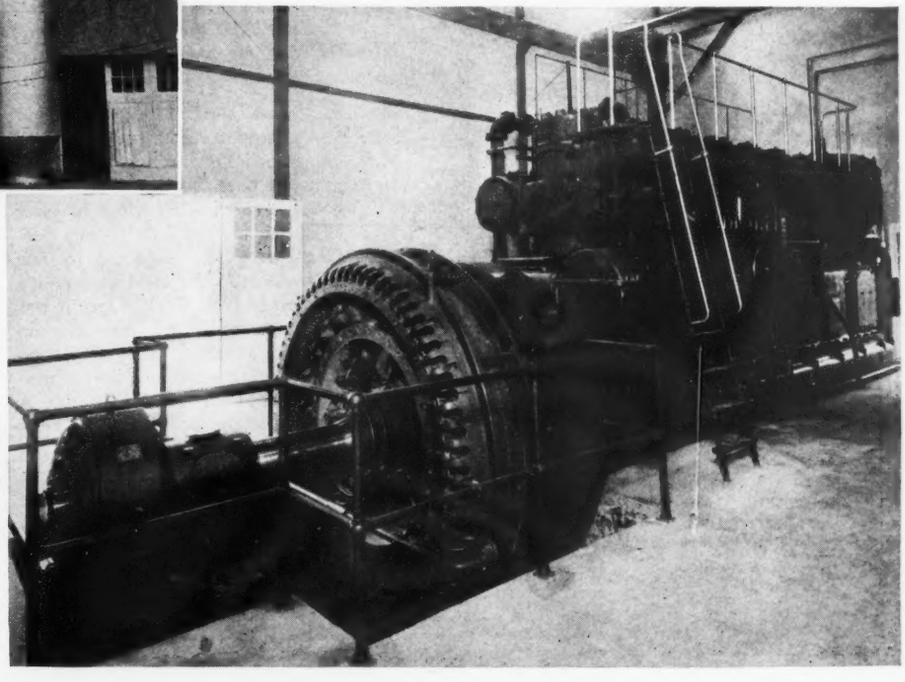
This city plant has an average gross revenue of $150,000 per year. Operating expenses for the diesel plant, maintenance of electrical distribution and water systems, and chemicals and maintenance for the filtration plant cost $80,000 per year, leaving $70,000 annually prior to retirement. This will be used to pay off a $70,000 indebtedness on filtration bonds, $52,000 in scrip certificates, and the $95,000 investment in the diesel ($80,000 plus interest for six years), a total of $217,000, which will be amortized over six years, leaving a $200,000 surplus.

Close-governed Diesel

The diesel is a 1,225-hp., Fairbanks-Morse, 7-cyl., 16x20-in., 2-cycle, solid-injection unit with oil-cooled pistons, positive scavenging pump and open heads, running at 300 r.p.m. It drives a 1,070-kva., 856-kw. @ 80% p.f., F.M., engine-type, direct-connected, 3-phase, 60-cycle, 2,400-volt alternator and a 20-kw. F.M., shunt-wound direct-connected 125-volt exciter. The engine is cooled with city-water overflow which drains back to the



Top—Exterior of the Lafayette, La., municipal power and water plant, built in 1925. Above—Concrete air-filter house with intake-air silencer mounted on top, exhaust silencer and stack, and 625-gal. fuel-oil day tank at left. This forms part of the addition to house the diesel. City water standpipe in background



Right—The 1,225-hp., 7-cyl., 16x20-in., 2-cycle, solid-injection diesel drives an 856-kw. direct-connected alternator at 300 r.p.m. and a 20-kw. shunt-wound direct-connected exciter. Control station shows the Woodward isochronous governor

underground reservoir. A Woodward governor remote-controlled from the switchboard insures constant frequency.

Fuel oil flows by gravity from railroad tank cars to a 25,000-gal. underground concrete storage tank. A ⅓-hp. motor direct-connected to a ½-in. F.M. rotary pump pumps it into a 565-gal. day tank, from which the built-in engine fuel pump takes it through a duplex strainer to the engine. An engine pump takes lubricating oil from the clean-oil tank and pumps it to all bearings and moving parts. An auxiliary 4-in. Roper rotary pump direct-connected to a 10-hp. F.M. 1,740-r.p.m. ball-bearing motor is provided for emergency. Oil is pumped through a Schutte & Koerting oil cooler, then through a duplex strainer to the engine. Wiper oil from the cylinders drains to a 3x5½-ft. dirty-oil tank, then goes to a Gould centrifuge driven by 1-hp. F.M. motor. The centrifuge has a 12-kw., 3-way heater. A 60-g.p.h. transfer pump draws oil from the main system through the centrifuge into a 3x5½-ft. clean oil tank, from which a second 60-g.p.h. transfer unit pumps it to the engine base as needed. Makeup is to the clean-oil tank.

Compressed air from two 26x96-in. air tanks on the engine-room floor starts the engine. A 2-stage, 475-r.p.m. 10.2-c.f.m., F.M. air compressor V-belted to a 3-hp., 1725-r.p.m., F.M. motor provides the air. Air for the engine itself comes from outside through a NOLA silencer into the concrete air filter house with 12 American air filters, then to the engine. Exhaust piping is steel, to an underground concrete silencing pit, then through a NOLA silencer to the stack.

The alarm gage panel has Marshalltown gages, high and low-pressure water, lubricating oil and scavenging air alarms. An Alnor pyrometer is also mounted on the panel board.

Fairbanks, Morse & Co., New Orleans, supervised all installation work. J. B. Mouton was sub-contractor for the foundation, Sammons Electric Co. for the switchboard and wiring, while the city itself contracted for the building addition. At the time of installation, Robert L. Mouton was mayor and J. Frank Ard superintendent. O'Neil Cormier is chief engineer of the plant.

EXHAUST LINES

By E. J. Tangerman

THE *New Yorker* tells the story of the little girl with green eyes and red hair who used to insist she lived in the big building on the corner of Fifth Avenue and 42nd St., New York, the one with the lions in front. That's the Public Library. Well, she *did* live there. Her name was Viviani Joffre Fedeler, and she was born in the Library and lived there for 14 years. Her parents have a 14-room apartment on the second floor, for her father is superintendent of the building. At 16, she married Charles Voelker, superintendent at 18 East 41st St. Met him at a Building Superintendent's Ball in the Hotel Commodore. She used to play with the Fisher kids across the street—their father was superintendent of the Rogers Peet Building. Mr. Fedeler became superintendent at the Library 25 years ago, and Viviani was his favorite assistant on visits of inspection to the Library power plant.

This business of living in buildings you'd never suspect had anything but offices in them is fairly common on Manhattan. One of the outstanding penthouse dwellers is Norman King, superintendent of the Singer Building, once America's tallest building. He's lived right on top of his job for years now. By the way his pet hobby is driving his car—he keeps careful graphs and charts to show costs per mile and all the rest of it. Says he, a car is just a power plant on wheels.

Here's a tip from Chief Engineer Wendland of the Empire State Building. He had a motor-driven pump that started and stopped automatically. He wanted to know how long it operated during the day. So he hooked an electric clock into the circuit. Now, when the pump starts the clock starts, and when the pump stops the clock stops. So, once a day he can read the hours and minutes of operation, then reset to 12 o'clock.

By the way, Engineer Wendland has five sons, and all are engineers. Bill is chief over at the Chrysler Building, so father and son operate the world's two tallest buildings. Charles, Jr., is Chief of the Great Northern Bldg., so that makes five stationary, five marine and three chief engineers in one family.

Sometimes a clock or instrument is in an out-of-the-way place where light is poor. To avoid stringing a light to it, or if it is best not to string a light there, use a mirror. Put the mirror in a well-lighted spot, mounted so that its beam strikes the object to be illuminated.

I've always sort of worried about these big outdoor clocks and wondered about the worries of the chief in a building that has one. Well, I don't worry anymore. Paramount Building in New York has one, but the Seth Thomas people take care of it, according to *The New Yorker*. 25 ft. in diameter, it's third largest in New York. Once it was lighted automatically, but now they do it with hand switches. They switch on the lights during snow and sleet storms too; that keeps ice off the hands. A curious updraught on Broadway gives the Thomas people some trouble, but outside that, this particular clock is very agreeable. Costs about $2600 a year to light it and take care of it. By the way, lighting the Empire State tower and upper 40 floors or so, now all untenanted, costs about $6,000 a year, but is considered well worth it in advertising value. Besides, if those upper floors aren't lighted, the tower seems to be floating around in the air.

A Long Island blueblood has had steam pipes laid under all the walks of his country place. A valve in the front hall takes care of his snow shoveling. Somewhat the same idea has been in use for some years out at Purdue University. There all the campus steam tunnels go along under the walks. Radiant heat keeps the sidewalks clear all winter. Tunnel ventilators come up at the sides of the walk, disguised as seats with a brick checkerwork base and limestone slab for a top.

We were sitting down in the office of Charles Koenig, chief in the Federal Reserve Bank Building, Cleveland. He noticed us sizing up a quart bottle full of a peculiar-looking whitish fluid that occupied a prominent place in the center of his desk. "Clam juice," he said, for he doesn't waste words. "We're going to have a clambake tonight. A bunch of us in the N.A.P.E. have been doing it for quite a while now."

From the Southeast comes the report of an ingenious method of cleaning boiler tubes. In a small laundry plant with two vertical boilers, the engineer (?) doesn't brush tubes anymore. He fills a 2-quart jar with gasoline, puts the cover on loose, tosses it through the fire door, and slams the door after it. There's a dull boom, a heavy belch of flame, cinders and soot out of the stack, and the job is done. Ingenious, but some day, he may come to with a tube or two wrapped around his neck.

THE NEW CEDAR RAPIDS "TOP"

*By John M. Drabelle & Walter H. Proescheldt**

Iowa Electric Light & Power Co.

A 700-lb., 765-deg., 300,000-lb.-per-hr. steam generator with water-cooled underfeed stoker will burn poor Iowa coals. Steam will drive a 7,500-kw. turbine, then exhaust at 215 lb. to the old plant

CEDAR RAPIDS plant is somewhat peculiar in that it furnishes large quantities of steam for industrial purposes and to a central heating system, thus in modernization the superimposed unit, or "top," is most adaptable to our conditions. Therefore, Iowa Electric Light & Power Co. will soon place in operation at Cedar Rapids a new Springfield 300,000-lb. per hr. steam generator making steam at 700 lb. per sq.in. and 765 deg. F.

Steam from this boiler will pass through a 7,500-kw., non-condensing General Electric turbine exhausting at 215 lb. and 150 deg. superheat directly into the present 210-lb. station header and designed with the superheater to give constant superheat. This header supplies steam in turn to five condensing turbine-generators and one 6,000-kw. non-condensing unit which in turn exhausts steam for the city heating system and to Quaker Oats Co. for process use. Fuel costs resulting from superimposing the high-pressure unit on the plant will be about 11,200 B.t.u. per gross kw.-hr.

Boilers

Two 210-lb. pressure boilers with total steaming capacity of 50,000 lb. per hr. were removed to provide space for the new unit—giving six times the former steam generation in the same floor space. The new 13,600-sq.ft. boiler is a cross-drum, 3-pass straight-tube type with interdeck Elesco superheater. Tubes in the lower bank slope at 15 deg. from the horizontal, while those in the upper bank slope at 25 deg. This promotes tube removal and gives better circulation in upper rows of tubes. A slag screen 17 in. deep, with tubes 10¾ in. apart, is provided and can be deepened if necessary to 27 in. without changing furnace volume.

Tubes are 3 in. in diam. by 19 ft. long, the upper deck having 52 tubes across and 10 tubes high, with provision for two additional rows, the lower deck one complete row of 48 tubes across, with provision for a second row. Below this deck is slag-screen space, and its tubes are 10¾ in. apart. Headers are cast electric-furnace steel. The all-welded drum is 54 in. inside diameter and 30½ ft. from centerline to centerline of the ends. All pressure parts are designed for 750 lb.

The furnace is completely water-cooled on all sides by a wall composed of 3-in. bare tubes on 3 5/16-in. centers, but protected in the coal area by iron blocks cast on the tube. Through the center of the furnace, a double water wall extends from below the stoker to within the superheater zone, composed of a double row of 3-in. tubes on 3 5/16-in. centers placed back to back. Coal from Atkinson, Ill., the ash from which melts at about 1,900 deg. F., will be burned in the furnace. This characteristic was a determining factor in design of the stoker, furnace, boiler and superheater.

A stoker was selected to burn a fuel with this low ash-fusion temperature. It is a Taylor water-cooled underfeed type developed from the experiments at this station during the last two years. (*Power*, page 694, Mid-December, 1935).

The stoker has 543 sq.ft. of surface (air admission part only), and it is not equipped with metered air control, although provision is made for it. Provision is also made for stoker removal, substituting pulverized-fuel firing if the stoker proves unsatisfactory. We expect to burn about 68 lb. of 10,436-B.t.u. coal per sq.ft. of stoker surface.

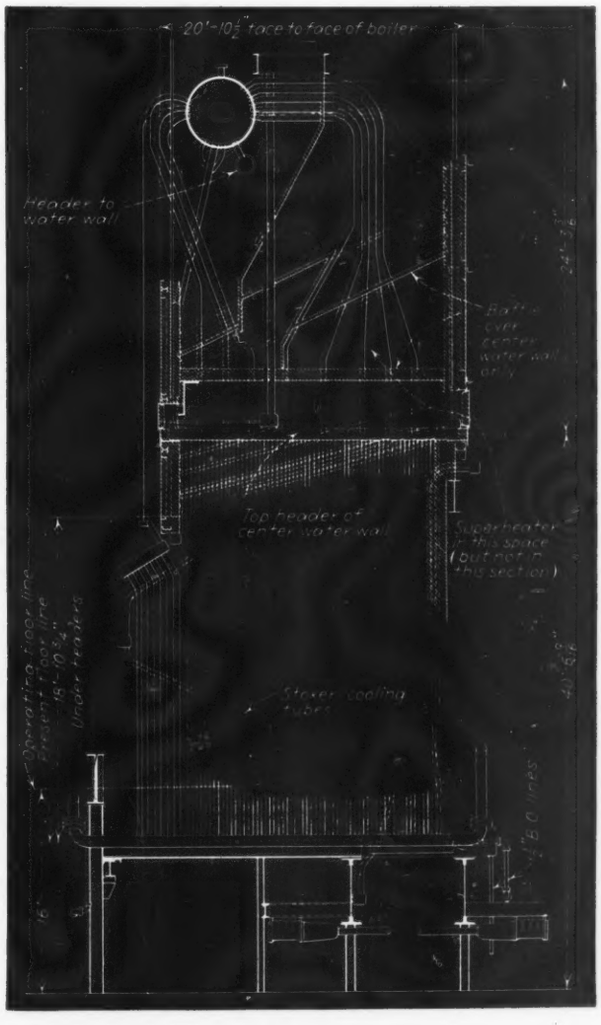
This station now has eight water-cooled underfeed stokers, most of them about 10 years old. Before tuyeres were water-cooled it was impossible to keep a boiler on the line for more than an hour when burning low-fusion-ash coal. We have successfully burned this coal at a rate of 55 lb. per sq.ft. of stoker area (air admission part only) with no ill effect on the stoker, limiting factors being sufficient air- and steam-relieving capacity of these old units. When tuyeres are water cooled, the effect is to freeze the molten ash quite some distance up in the fuel bed, allowing unrestricted flow of air and proper functioning of the stoker.

Effective furnace volume is about 7,500 cu.ft. Expected temperature of gas leaving the furnace at 300,000 lb. of steam per hr. is 2,210 deg. F., dropping to 1,970 deg. at 200,000 lb. per hr. and to 1,650 deg. at 100,000 lb. per hr.

A 4,608-sq.ft., Foster Wheeler, extended-surface economizer 8 rows high, 12 tubes wide and 16 ft. long is installed. Provision is made for four additional rows of elements. The Ljungstrom air heater has 29½-in. elements, but provision is made for 44-in. elements. Forced-draft fans are Sturtevant units equipped with vane control, and induced-draft fans are American Blower units equipped with dust collector. No boiler feed pump was purchased.

This addition brings the plant in line with more modern stations, because, of course, building, water supply, tunnel, stacks screen house, coal handling, electrical year, etc., are in accordance with present practice.

*An abstract of a paper presented before the Iowa Engrg. Society in Cedar Rapids, week of March 10.


20'-10½" face to face of boiler
Header to water wall
Top header of center water wall
Superheater in this space (but not in this section)
Stoker cooling tubes

Cross-section of the 300,000-lb.-per-hr., cross-drum boiler through the center water wall showing how stoker cooling is tied in with boiler circulation

FIRE HAZARDS IN ELEVATOR HOISTWAYS

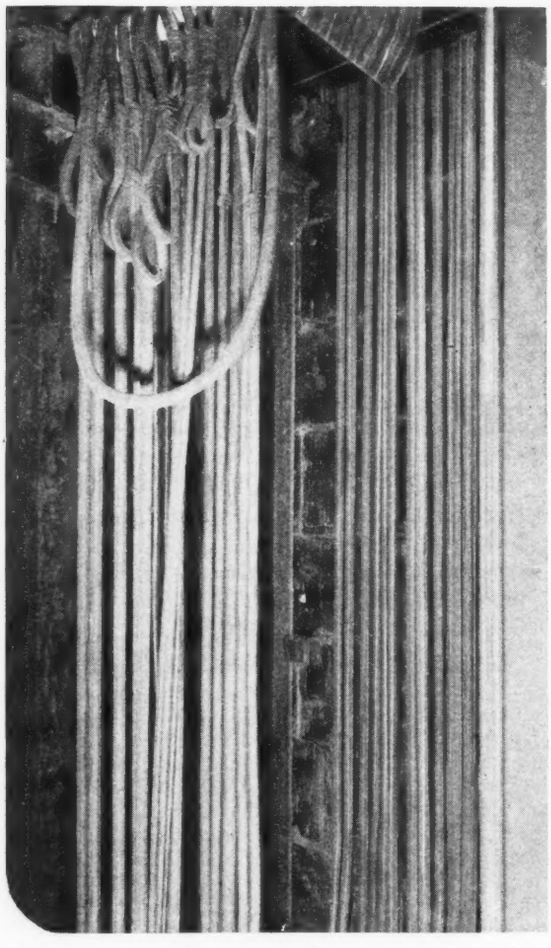
MAKING elevator hoistways fireproof has not removed the fire hazard from this equipment; it has only helped to keep outside fire from getting in. But possibilities for serious fires starting in the hoistway may still remain. With modern high-speed automatic elevators, this hazard has been greatly increased because of the large number of multi-conductor cables required to connect car control and signal devices with the machine-room and other equipment.

A modern high-speed automatic elevator may have 20 or more multi-conductor travelling cables leading to a terminal box midway up the hoistway. These cables may be up to 400 or 500 ft. long, depending upon hoistway length, and each may contain from 2 to 20 or more insulated conductors. In service, these cables may become laden with dust, oil vapor and other inflammable substances. Car floors are of wood; frequently car sides are wood veneer on sheet metal. Guide shoes and guide rails are lubricated and naturally pick up dust and dirt. Oil, dust and dirt collect on the hoistway wall and car; to what extent this occurs depending upon how well the cleaning job is done. Thus everything is available in the hoistway to start a dangerous fire.

All that is needed is something to start it, and this is ever present in the cables. As the car travels up and down, they bend continually and in long hoistways are subjected to considerable stress because of their weight. These actions gradually fatigue the wires and they break, possibly forming an electric arc that will burn through the cable covering and ignite the light combustible material on the outside. Such a flame, once started and fanned by hoistway air currents, may spread rapidly over the cable and develop into a serious fire.

What Fire Can Do

A recent fire in a 48-story office building shows what can happen when elevator cables catch fire. In this case two cars operated in adjacent hoistways inclosed by fireproof walls. Travelling cables on one car caught fire, and the resulting fire totally destroyed this car and its control cables, and made it necessary to replace hoist and governor ropes on both cars. The heat was so intense that the hoist ropes on one car parted. Fortunately, it was at the top floor. The governor and safety ropes held and set the safeties on the car, stopping it at the 46th floor. The counterweights dropped only a short distance onto the hydraulic bumper, so did no damage.



When a fire gets started in a mass of traveling cable like this it may develop into a catastrophe

Hoistway doors were badly distorted with the heat on several floors, and the fire came through the doors on the two upper floors and did considerable damage.

Fire-insurance and building engineers who investigated were of the opinion that this fire could be due only to a short-circuit or an open circuit in the control cables from causes previously outlined. Conclusions and recommendations regarding the control cable are:

1. This experience demonstrates that with many control cables having combustible covering suspended under the bottom of each car and relatively close together, a fire starting in the cables will quickly spread and travel upward, producing a great deal of heat and smoke. If the car should be filled with passengers, panic and even loss of life might result.

2. At the time the building was constructed it was common practice to use control cables covered with combustible material. This experience demonstrates that such installations may be serious hazards. It is therefore recommended that existing cables be replaced with cables having flame-retarding outer covering.

Elevator cables in the past have been designed and built to obtain flexibility, long life and possibly a moderate amount of resistance to moisture. Such cables

operate well under ordinary conditions, but in the presence of fire they may be adding fuel instead of retarding the fire. Because of this, a great deal of study has been devoted to developing flame-resisting cables, and several are now available.

Any cable to suit modern elevator conditions must not carry flame along its outer surface. It must also be capable of withstanding a severe fire and still give some electrical insulation and service.

The specifications for one of these cables requires that each conductor shall be of soft annealed copper wire, bunch stranded and covered with a separator of fine-cotton yarn. Over the cotton-wound conductors a wall of 30% colored, slow-ageing, flame-resisting, rubber insulating compound is applied. Outside the insulated conductor there is a wall of fireproof material, not less than 0.015 in. thick, saturated with a moisture- and fire-resisting compound.

Conductors are assembled concentrically, with core and interstices filled with fire-proof material. Over the cabled conductors there is a rubber-filled tape not less than 0.008 in. thick, frictioned on one side only, applied with the plain side next the cable. Over the taped cable is a substantial braid of fireproof material saturated with a moisture- and fire-resisting compound and finished with powdered mica.

The insulating compound must meet rigid accelerated ageing and physical requirements and dielectric and insulation-resistance tests. The fire-resisting test on the cable consists of supporting a 4-ft. sample of the complete cable in a horizontal position in a room free from drafts. A bunsen burner having a 0.25-in. inlet and 0.4-to 0.5-in. diameter mouth is so adjusted that the outer cone of flame is 5 in. long and the inner blue cone 1.5 in. The flame is placed so that the inner cone just touches the cable and is applied for 2 min. The sample is considered meeting the fire-resisting requirements when the cable does not burn for more than 5 sec. after the burner is removed. After this test the sample is required to meet standard electrical tests.

Such cable, although not absolutely fireproof, possesses in a high degree qualities that will resist fire, due to using fireproof material where possible and to saturating materials that give off small quantities of inert gas for smothering any flame that might develop.

Modern high buildings are practically fireproof, but fires do occur in them. When they do, the important service in the building is the elevators, to get people out as quickly as possible. Travelling cables are the most vulnerable part of an elevator system when a fire occurs. Therefore, it is imperative that they be as nearly fireproof and waterproof as possible.

BRONZE-WELDED CONDENSER TUBES—Four years of successful operation have convinced engineers of a metropolitan power company that bronze-welded joints for admiralty metal (copper alloy) water condenser tubes are satisfactory. In 1931, due to corrosion of the former type of joint, a better joint was sought. Bronze was tested, and late in the year, 1,500 bronze-welded tubes were placed in service. A simple butt-type joint was found best. No trouble from joint corrosion has been noticed since.

▼ ▼ ▼

THE ASH ALLEY COMES CLEAN

By S H. Coleman

As is often the case in power plants designed a few years ago, the ash alley of a large stoker-fired industrial boiler plant was responsible for a number of operating and maintenance troubles. Frequent breakdowns of ash-disposal conveyors, high lighting-circuit repair costs and periodic flooding of the alley with ash-pit cooling water were among the many difficulties.

Most of these troubles were directly traceable to undesirable working conditions caused by inadequate ventilation, excessive heat, faulty illumination and poor drainage. Operators and mechanics anxious to get out of the place as quickly as possible performed their duties haphazardly. Equipment failures due to overloading, lack of lubrication, accumulations of material beneath conveyor buckets, and careless repair practices were the inevitable result.

To improve working conditions, a number of changes were instituted. These improvements, costing very little, substantially reduced operating and maintenance costs, improved ash-alley housekeeping and did much to raise the morale of the plant employees.

Illumination difficulties were first corrected. The original lighting circuits, badly deteriorated by heat and moisture, were completely renewed. In the new installation, all conduit joints were waterproofed and lead-covered wire pulled in. Substitution of vapor-proof fixtures greatly reduced lamp-base corrosion troubles. Enough fixtures were provided to insure sufficient lighting.

An exhaust fan was added to eliminate ventilation troubles and reduce the temperature materially. The fan also dried walls and ceiling formerly continuously wetted by condensing vapor.

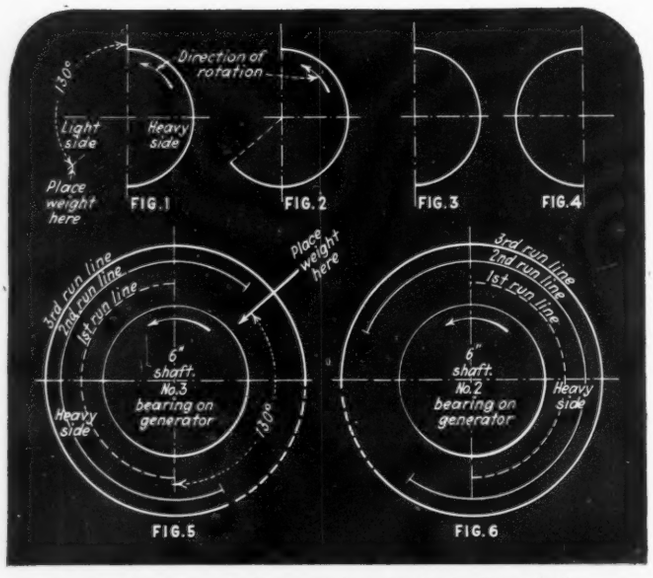
An existing steam syphon was placed in standby service and a sump pump provided. This pump, having hardened-steel working parts to withstand the abrasive action of any ash which might gravitate to the sump pit, was of sufficient capacity to handle large quantities of clean-up water in addition to normal drainage. This made possible an appreciable reduction in fuel consumption and eliminated inherent suction troubles responsible on many occasions for flooding.

Housekeeping was promoted by installation of a high-pressure water line with hose valves at a number of points along it. High-pressure hose streams greatly assist in the removal of ash accumulations from relatively inaccessible points.

TURBINES BALANCED BY PENCIL

By Fred E. Schubert

Chief Engineer
Municipal Power Plant,
Columbus, Ohio



How to balance turbine-generator rotors by holding a lead pencil against the shaft to locate position of unbalance

NEW turbine-generators installed at our plant were left in what the erecting engineers termed good balance, but far from satisfactory to me. For instance, the pointer of a dial indicator placed on the shaft of one machine whipped around so badly that a reading could not be taken when running at full speed (3,600 r.p.m.) and full load. A few weeks of such operation caused serious trouble from valve gears working loose and sparking at the slip-ring brushes. This was all eliminated by proper balancing of the machine which we did ourselves.

We now never have a sign of sparking at slip-rings, and use the softest of graphite brushes with a spring pressure not exceeding 1 lb. per sq.in. of contact area. All brushes and collector rings run cool, and the soft brushes give six months or more service. We have had service engineers attempt to grind collector rings at full speed (3,600 r.p.m.), taking several days to do the job —and fail. We balanced the unit and then ground the rings at slow speed and had no further trouble with the rings and brushes. In fact, slip rings ground eight years ago are still operating satisfactorily.

In many plants, turbine-generators are dismantled for overhauling once each year. This may be necessary where units are not correctly balanced, but since we have balanced our units properly, a complete overhauling every four years is sufficient. Our units include a 7,500-kw., 3-bearing, a 6,000-kw., 4-bearing, and a 4,000-kw., 4-bearing machines, all at 3,600 r.p.m.

When balancing the machines, I apply whitening to the shaft with a small camels-hair brush, and hold a fine-pointed 6H lead pencil against the shaft while the machine is run about 5% above normal speed. If the unit is out of balance, a mark extending, say, halfway round the shaft is obtained, as in Fig. 1. By placing about 5 oz. of weight at 130 deg., on a 10-ton, 3,600-r.p.m. rotor, as indicated in the figure, one will, if he holds the pencil correctly, get a lengthening of the line around the shaft, as in Fig. 2. This would indicate that the weight should be moved back, say, one hole in the rotor. The next trial should lengthen both ends of the line. This would indicate that the position of the weight is correct, but is too small.

When making preliminary balance runs I sometimes find that a line is obtained on one side of the rotor shaft at one end, as in Fig. 3, and at the other end the mark is on the opposite side of the shaft, Fig. 4. I have found that by carefully manipulating 5- to 6-oz. weights on a 10-ton rotor, practically perfect balance can be obtained. (Many engineers use weights that are too heavy to start with.) Weights are placed one at a time, a run made and pencil lines obtained at each end of the shaft, and compared. I always run a line at each bearing and compare.

Figs. 5 and 6 show how one job was done on a 7,500-kw. 3,600-r.p.m. 3-bearing unit with rigid coupling. The first-run pencil test produced the half circles on the shaft, marked 1st run line. The unit was shut down and a 6-oz. weight placed on the rotor 130 deg. in advance of the end of one line. Another run gave the line marked 2nd run. Four ounces more weight added at the 130-deg. location and a third run gave the lines marked 3rd run. The unit was now running so smoothly it scarcely operated a vibrating-type tachometer. A dial indicator placed on the shaft when running 3,600 r.p.m. gave readings of 0.001, 0.002 and 0.003 at Nos. 1, 2 and 3 bearings respectively.

The generator rotor, Figs. 5 and 6, was out of dynamic balance at each end, and sometimes it is necessary to add weight at both ends of the rotor to correct the balance. It has also been necessary in some cases to add weight to the turbine rotor. On the 7,500-kw. unit, 10 oz. at one end of the rotor corrected the trouble. A dial indicator will show the bearing at which the unit is most out of balance. At this end the weight should be placed first.

An interesting result of this work is reduction in bearing temperatures. Proper balancing of a 3-bearing machine reduced the middle-bearing temperature 16 deg. F.

Difficulties of obtaining good running balance in turbine-generators, remarked by the author, may have been true several years ago. Modern devices, however, insure a high degree of balance.—Editor.

CONVERSION ON SPRINGS

At Safe Harbor, a 31,500-kva. converter tying the main system and railroad load has a spring mounting and hydraulic frame shifter

By A. M. Goodison

Power Engineer
Westinghouse Electric & Mfg. Co

AT ITS Safe-Harbor plant, Safe Harbor Water Power Corp. installed a 25,000-kw., single-phase, frequency-changer set. Design of the hydraulic frame-rotating device on the 60-cycle, 3-phase machine and the spring support between frame and foundation on the 25-cycle, single-phase unit are unusual.

The set, Fig. 2, supplies power to the Pennsylvania Railroad. The generator is rated 31,250 kva., 25,000 kw., 0.8 p.f., single phase, 13,300 volts, 25 cycle, 300 r.p.m.; and the motor 35,000 hp., 29,700 kva., 0.90 p.f., 3 phase, 60 cycle, 13,800 volts. Both ends are designed for a temperature rise of 80 deg. C. by detector and resistance on the stator and rotor respectively.

To meet requirements of railway service, the 25-cycle machine is designed to operate from 8,500 volts no load to 14,300 volts, 31,250 kva., 0.8 p.f., over-excited continuously; to 14,300 volts, 54,700 kva., 0.8 p.f. over-excited for 1 min. to 14,000 volts, 62,500 kva., 0.8 p.f., over-excited for 1 min. The motor is to operate over a wide range of 12,000 volts no load to 14,500 volts at all loads corresponding to generator loading. In addition, the motor is designed to stay in step for 2 sec. with 50% voltage impressed across its terminals and with normal full load or a fluctuating load from zero to normal full load.

A recirculating system of ventilation is provided in which air discharged below the machines into the pit returns to the space above the floor line, through ducts and water coolers under the floor. A welded steel housing covers the machines, which are out of doors.

The motor frame rests in a cradle supported by the foundation, Fig. 3. Loose frame feet, mounted on the bedplate, act as guides at the point normally occupied by stationary frame feet. Bearing surfaces of the cradle and feet are adequately lubricated. The shifting device contains two cylinders, one on each side of the machine's center line, with a common plunger attached at its center to the machine frame by links. Horizontal movement of the plunger is transmitted to rotational movement of the frame through these links. Plunger movement is controlled by admitting oil under high pressure to the cylinders. Oil is pumped into one cylinder for one direction of rotation of the frame, thereby moving the common plunger and forcing oil out of the other cylinder

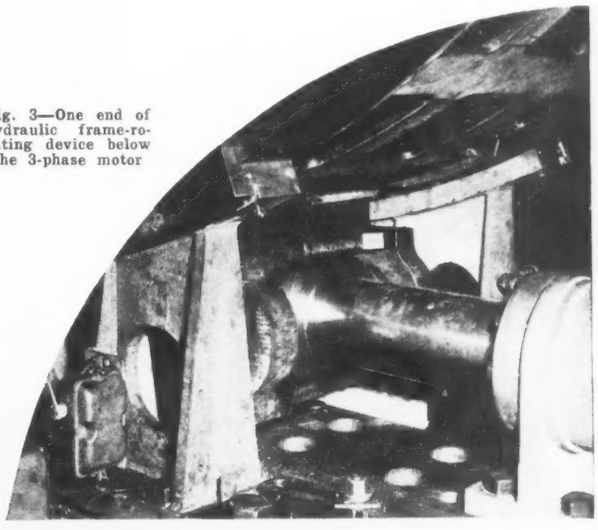


Fig. 3—One end of hydraulic frame-rotating device below the 3-phase motor

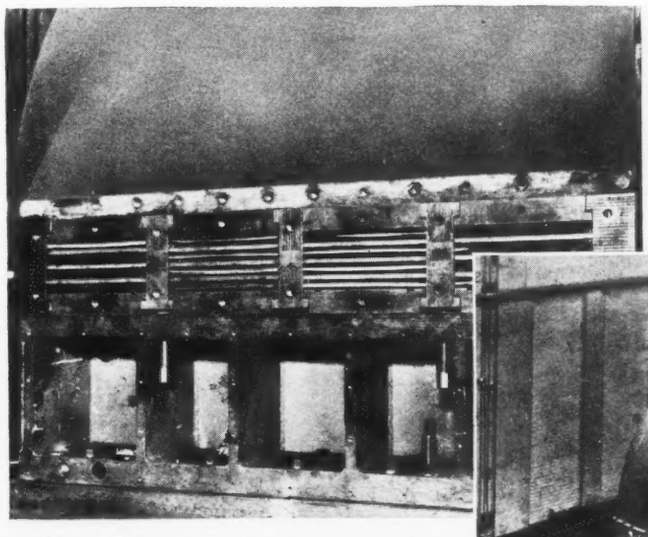


Fig. 1—Spring support between generator frame and bedplate to prevent transmission of pulsating torque, characteristic of a single-phase machine

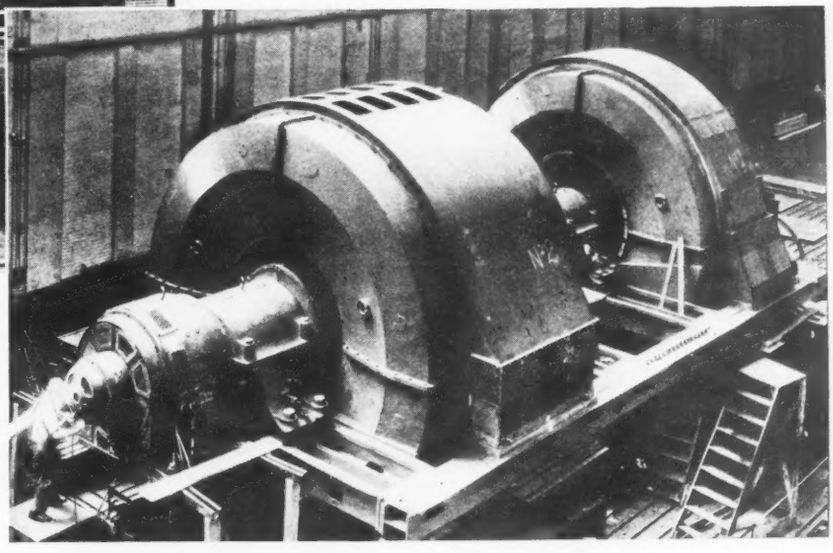


Fig. 2—Frequency-changer set comprises a 31,500-kva., 13,300-volt, 25-cycle, single-phase generator and a 35,000 hp., 13,800-volt, 60-cycle motor

and into the suction of a Hele-Shaw high-pressure pump. A magnetic brake attached to the motor stops it quickly when power is shut off. Direction of rotation is controlled by the direction of rotation of the pump, although this could be accomplished by adjustment of a hand-wheel.

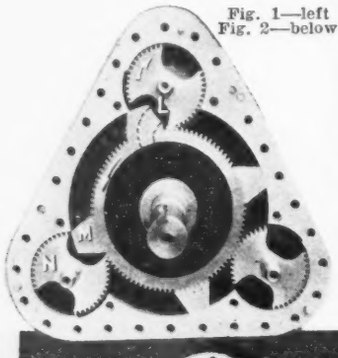
To prevent transmitting the pulsating torque, characteristic of a single-phase machine, to the foundation and building structure the generator frame is supported on a spring system. Fig. 1 shows the spring support, which consists of a number of flat springs spaced and supported on fulcrums to provide free vertical spring action. A high-strength spring steel is used, similar to that in locomotive springs.

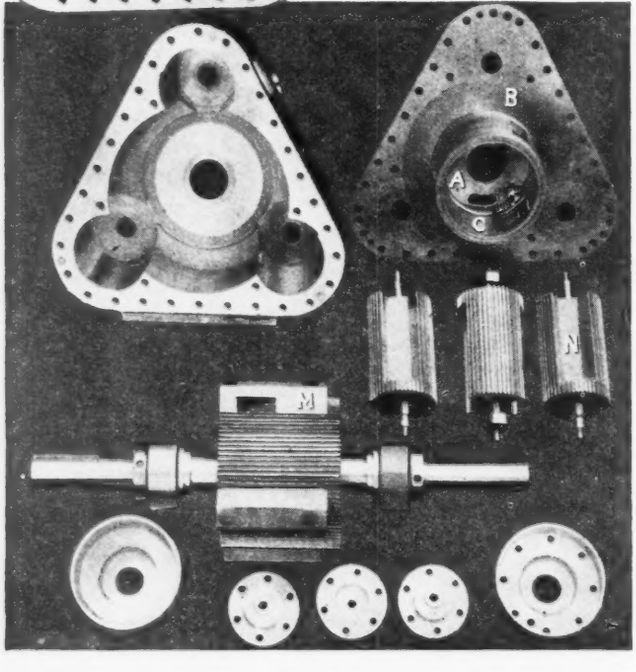
The system is so designed that with the frame static load and torque equivalent to full-load, the springs will not deflect sufficiently to permit the spacer blocks to come in contact. Thus, the stator is permitted to oscillate at double frequency with complete freedom. In event of a short circuit, the frame is subjected to a torque much in excess of normal. In this case, the springs deflect to the extent that the blocks attached to frame and foot will contact loose members in the assembly, thereby bringing the springs into action for both directions of torque pulsations. Even under short circuit, there will be a positive clearance between the actuating blocks.

ROUND AND ROUND

SMALL size and light weight are characteristics of the "Kinetic" uniflow steam or air engine just developed in Canada. Illustrated is an experimental 3-cyl., 4-piston unit. Steam or compressed air is supplied at the center through the adjustable cut-off sleeve and ports B, Fig. 2. It then passes through cored passages in the pistons as shown by the dotted lines entering chamber L, Fig. 1. Pressure in this chamber causes counter-clockwise rotation of the piston and clockwise rotation on the gate gear (because of greater area created by exposed gear-tooth face.) As the piston moves around, exhaust port M is uncovered. Then the piston passes through the next gate gear N, for its next power stroke. Thus each piston receives three power impulses per revolution, a total of 12 for this unit. Cut-off is adjustable by rack and pinion C to admit full pressure during any desired part of the power stroke, and gate valves are constantly geared to piston by gearing at back. At 2,000 r.p.m. and 600 lb. pressure, a similar 4-cyl., 3-piston unit produces 50 hp., is 9½x9½x10 in., weighs 110 lb.

Fig. 1—left
Fig. 2—below





TEST

By Walter H. Wood

Combustion Engineering Co., Inc.

RESULTS of an ordinary boiler test are arrived at by very simple calculations. But it is important that the reason for each step in the work be fully understood. An example is probably most satisfactory in illustrating the method, so here are data from a typical test:

Item No.	
1	Duration of test, hr.	10.0
2	Number of boilers tested	one
3	Kind of boiler	Sectional-header water-tube
4	Total water heating surface of boiler, sq.ft.	3,916
5	Kind of grate	Shaking grate, ⅜-in. air space
6	Width of gate, ft.	10.0
7	Length of grate, ft.	7.0
8	Area of grate, sq.ft.	70.0
9	Average pressure in boiler, by gage, lb. per sq.in.	147.3
10	Average draft, boiler side of damper, in water	0.84
11	Average draft in furnace, in. water	0.43
12	Average temp. feedwater entering boiler, deg. F.	119.5
13	Average temperature of gases leaving boilers, deg. F.	541
14	Av. temp. steam in low-press. side calorimeter, deg.F.	281
15	Kind of fuel burned	Penn. Semi-bitum. run-of-mine
	Analyses of Fuel, as fired, %	
16	Moisture	4.66
17	Volatile matter	21.92
18	Fixed carbon	67.20
19	Ash	6.22
20	Sulphur	1.69
21	Heat value per lb., B.t.u.	14,091
22	Total amount of fuel burned, lb.	20,705
23	Total heat input to boiler, B.t.u.	291,754,155
24	Fuel burned per hr., lb.	2,071
25	Fuel burned per hr. per sq.ft. of grate area, lb.	29.6
26	Refuse from cleaning fires during test, lb.	1,433
27	Per cent of refuse referred to fuel burned	6.92
28	Moisture in steam by throttling calorimeter, %	1.407
29	Quality of steam generated, referred to dry steam as unity, %	98.593
30	Water fed to boiler, lb.	183,025
31	Total heat output from boiler, B.t.u.	211,346,088
32	Heat output per hr. from boiler, B.t.u.	21,134,608
33	Per cent of boiler rating developed	161.5
34	Combined efficiency of boiler and furnace, %	72.4

The first eight of these items are general information which should be recorded at the time the test is made. Items 9 to 14 inclusive are the averages of observations made during the test. The kind of fuel burned, Item 15, should be ascertained and recorded for future reference, and for the purpose of comparing results obtained with various fuels. The results of fuel analysis (Items 16 to 21 inclusive) are furnished by a laboratory. These should also be preserved as a matter of record. The amount of fuel burned, Item 22, is obtained from the record of coal weighed during the test.

Item 23, total heat input to boiler, is found by multiplying Item 22 by Item 21, and gives the total amount of heat (in B.t.u.) in all of the fuel burned during the test. Item 24 is obtained by dividing Item 22 by Item 1, the duration of the test, in hours. The rate of combustion, Item 25 = amount of fuel burned per hour (Item 24) divided by the area of the grate in sq.ft. (Item 7). The amount of refuse from the cleaning of fires is taken from the data recorded during the test. The amount of the refuse, divided by the amount of fuel fired (Item 22) is the per cent of refuse, referred to the total fuel burned (Item 27).

Item 28, per cent of moisture in the steam, is determined by a throttling calorimeter.

The design of the calorimeter is based on the fact that when steam is expanded through an orifice, there is no loss in heat in the steam, except that due to radiation. If the calorimeter is properly insulated, radiation loss

YOUR OWN BOILERS—VIII

CALCULATING RESULTS

can be neglected. Since the amount of heat in the steam is the same on both the high-pressure and the low-pressure sides of the orifice, the steam on the low, or atmospheric, pressure side will be superheated. Moisture present in the steam, will be evaporated by the superheated steam. The degree of superheat as indicated by the thermometer on the low-pressure side of the orifice will therefore depend on the amount of moisture in the steam.

The formula for calculating the amount of moisture in the steam is

Per cent of moisture =

$$\frac{H - 1150.2 - 0.47\ (t - 212)}{L} \times 100$$

where H = total heat in steam entering the calorimeter (assumed to be at boiler pressure)

t = temperature of steam after passing through orifice of calorimeter

L = latent heat of steam entering calorimeter (assumed to be at boiler pressure)

1150.2 = specific total heat of steam at atmospheric pressure

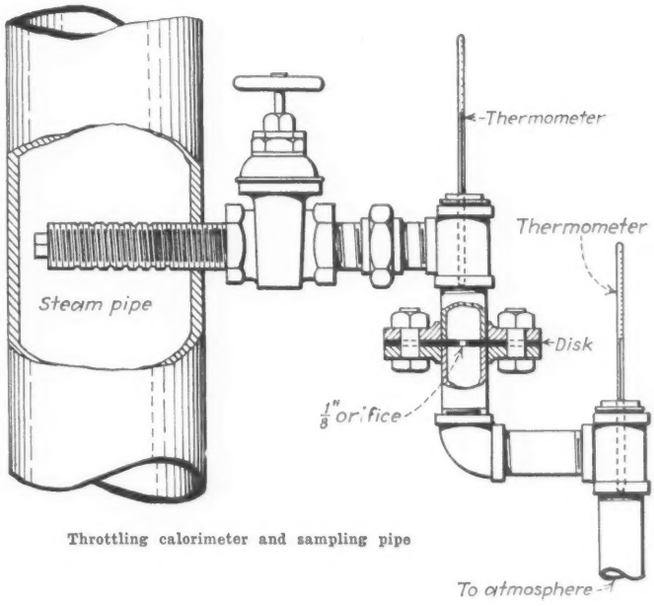
By referring to a table of properties of steam (Keenan), the total heat in a pound of steam at boiler pressure, 147.3 lb. gage (162 lb. abs.), is 1194.7 B.t.u., and its latent heat is 857.8 B.t.u. Specific heat of superheated steam at atmospheric pressure is 0.47. Temperature of steam after expanding through the calorimeter orifice is 281 deg. Substituting these values in the above equation, the per cent of moisture in the steam is found to be:

Moisture =

$$\frac{1194.7 - 1150.2 - 0.47\ (281 - 212)}{857.8} \times 100 = 1.407\%$$

Of the total water fed to the boiler, (183,025 lb.) as shown in Item 30, 1.407% or 2,575 lb. was heated from 119.50 to the temperature corresponding to 147.3 lb. gage, but was not evaporated into steam. The heat in each pound of the feedwater (at 119.5 deg.) above 32 deg. is 119.5 — 32 = 87.5 B.t.u. The heat in one pound of water above 32 deg. F. at the temperature corresponding to 147.3 lb. gage is found from the steam table to be 336.91 B.t.u. Therefore 336.91 — 87.5 = 249.41 B.t.u. were added to each pound of the moisture in the steam, representing a heat input to moisture in steam of 2,575 x 249.41 = 642,230 B.t.u.

Since 1.407% of the water fed to the boiler remained as moisture in the steam, 100 — 1.407 or 98.593% of the water was converted into dry steam. The total heat in 1 lb. of dry steam at 147.3 lb. gage is 1,194.7 B.t.u. and the heat in 1 lb. of feedwater above 32 deg. is 87.5 B.t.u. Therefore each pound of steam generated received from the fuel 1,194.7 — 87.5 = 1,107.2 B.t.u. The heat in the dry steam generated was therefore 193,025 x 0.9859 x 1,107.2 = 210,703,858 B.t.u. The total heat



Throttling calorimeter and sampling pipe

output of the boiler during the test was the sum of the heat in the moisture in steam and the heat in the steam generated, or

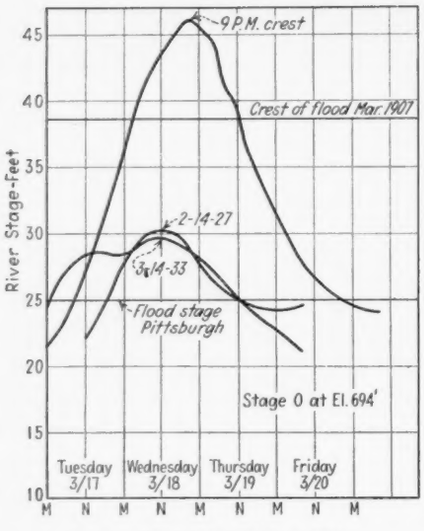
210,703,858 + 642,230 = 211,346,088 B.t.u. or 21,134,608 B.t.u. per hr.

It is common to assume that a boiler is operating at its rated output when delivering 3,347.2 B.t.u. per hr. per sq.ft. of heating surface. Thus the rated output of this boiler is 3,916 x 3,347.2 = 13,107,625 B.t.u., and during the test it operated at $\frac{21,134,608}{13,107,635} = 161.5\%$ rating. This method of rating a boiler comes from the old term "boiler horsepower" which now has little significance.

The efficiency obtained on the test, as noted in the first of this series of articles, is the ratio of the total heat output (Item 31) to the total heat input (Item 23). This is therefore

$$\frac{211,346,088}{291,754,155} = 72.4\%$$

Other results are often calculated, but the foregoing are the principal data desired. It is quite common for example to find such items reported as "evaporation per pound of coal as fired," or "equivalent evaporation per pound of coal as fired," and "per pound of dry coal." Such information is usually of little value, because the heat values and the kinds of coal burned vary so much that "evaporation per pound of coal" has little meaning. Since we are interested principally in rate of generating steam, and in efficiency that is obtained by the unit, it is a more simple matter to confine calculations to heat output, expressed in B.t.u., and to efficiency developed.



The record-breaking flood at Pittsburgh, and some earlier crests

POWER and the FLOOD

What happened at Pittsburgh and Hartford, and how central stations have started to repair the damage

When news of the power failure at Pittsburgh was received in New York, POWER immediately began making arrangements to get an editor into the stricken area. R. B. Purdy, associate editor, flew there Friday, March 20, and stayed two days. F. A. Annett, associate editor, is in the New England flood area at the time this is written. Here is Purdy's eye-witness account—Editor.

FRIDAY, March 20. Two days ago, the flood rolled over the "Golden Triangle," pride of Pittsburgh's business district and center of the steel industry. Militia now have drawn a ring of steel around the flooded city, and power stations are out, wires are down, roads are under water. The sole remaining link between Pittsburgh and the rest of the country is the airplane. After two days' delay, I have at last been seated in a TWA plane making an extra flight.

I fly to McKeesport, then by car into Pittsburgh. The lobby of the William Penn is lit only by two flaring, guttering emergency gas lights. No elevators are running, so I walk up the seven flights to my room. Stairways are lit by candles. The bellhop pulls a candle stub from his pocket to guide me through the pitch-dark halls. One lantern lights my floor. There is no water; pumps won't lift water to the house tanks without electricity. Militia have shut off any flow of other liquid refreshment, so I drink tea for three solid days.

Only under these conditions does one begin to realize how essential electricity has become in our everyday lives. Life of the city is disrupted, disorganized, because one service is lost. Yet, officials of Duquesne Light Co. tell me that the great objection to power failure is not the loss of light, but of power for the radio, for even in disaster, people must know what's going on.

Essential equipment in the three power plants of the Duquesne Light Co.—Brunot's Island, James H. Reed and Colfax—was submerged by the flood waters of the Allegheny and Ohio rivers, which rose to the all-time record of 46 ft. as shown by the graph. The first station to shut down was Brunot's Island plant at 7:30 A.M. Wednesday, followed by J. H. Reed Station at about 11 o'clock. About 4 hours later, Colfax Station went out although it was thought up to the last minute this plant would weather the flood. This left the Duquesne system without any generating stations in service, and because of an earlier shutdown of a tie with West Penn Power Co. the entire system was dead. Up to the time Colfax shut down, service was continued to the then-flooded "Golden Triangle" district even though underground cable ducts and transformers were submerged.

At the power plants, checks were made regularly with the weather bureau and army engineers as to the expected height of the flood crest. Based on reports from them the record flood that actually came was not expected. Nevertheless steel bulkheads had been bolted in place at all openings. They were designed for several feet more of water than existed at any previously recorded flood. Actually these bulkheads were topped by the flood, hence water could not be kept out. In addition, some water seeped in through the basement concrete.

At both plants the water stood about 3 ft. above grade, which, since the turbine room is approximately at grade, meant 3 ft. above the turbine-room floor. However, pumping and bulkheads kept the water level down to 2 ft. in the condenser room at Reed. No water was in the boiler room. At Brunot's Island plant, at the same site as Reed, the water was 8 ft. deep in the old boiler room and the generators were partly under water. At Colfax the water flooded the condenser room to within 6 ft. of the turbine-room floor.

When it was seen that flood would submerge the basements of the power plants, efforts were made to remove as many motors as possible to locations that would keep them dry. At each plant this was carried out sufficiently to have enough dry motors to start up one unit. All motors were removed from the machine shops, and this has proved extremely important as these shops are now available for work necessary to get the plant into operation.

Steam pressure was maintained at Reed, but at Colfax the boilers were banked as soon as boiler feed was lost. At the present writing, Colfax and Reed have been unwatered and available dry motors are back in place. Temporary cable is being laid to them, no attempt being made to draw from conduit the cable that had been submerged. Temporary controls are in. Considerable progress has been made toward cleaning out the mud from the equipment and bearings as well as from the building.

At the Stanwix heating plant, where 8- and 9-ft. bulkheads had been installed, the water stood 10 to 12 ft. in the boiler-room basement, but not up to the firing floor. All condensate was polluted due to river water entering the tanks but nevertheless it is being used as boiler feed, and the boilers are in operation supplying steam to street mains not submerged. Tunnels carrying steam mains are being pumped out before steam is turned on, hoping by this procedure to save pipe insulation, which experience has taught is ruined if steam is turned on while the mains are submerged.

At about 4:30 p.m. Wednesday, a tie was made with Ohio Power Co., which gave something less than 1,000 kva. of capacity. Two hours later a small-capacity tie was made with West Penn Power which established lighting service at Colfax. At about 8 p.m., a tie was closed with Pennsylvania & Ohio Power Co., which gave service to J. H. Reed station and Brunot's Island. Later that evening service was given to the main telephone building and for ventilation of the Liberty tubes. By Friday, sufficient ties had been made with West Penn, Pennsylvania &

1,200-kw. Scotland Dam Plant, destroyed by ice March 12

Ohio Power, and Ohio Power to make about 40,000 kw. available.

The 66-kv. outer ring substations feed at 22 kv. to inner ring substations. As fast as these ties could be checked inner ring substations not flooded and found serviceable were made alive. Through night and day work of the entire distribution force, service had been reestablished by Friday afternoon for police and fire signals, telephones and telegraph, water pumping plants, hospitals, dairies and bakeries, 60% of street lighting and about 25 street cars. As conditions permit, it is planned to restore power for newspaper plants, domestic lighting, commercial light and power and finally to industrials in the order given.

Underground transformer vaults in the flooded area are provided with drains, but many are known to be plugged. The extent of the damage to this low-voltage network is yet unknown, and pumping to unwater flooded vaults has been carried on to a limited extent. At present it appears that most damage has been to the 4-kv. system feeding the downtown area. The immediate need is to establish emergency power to necessary services, and in some cases this is being done by stringing wires from building to building above the streets and installing portable substations.

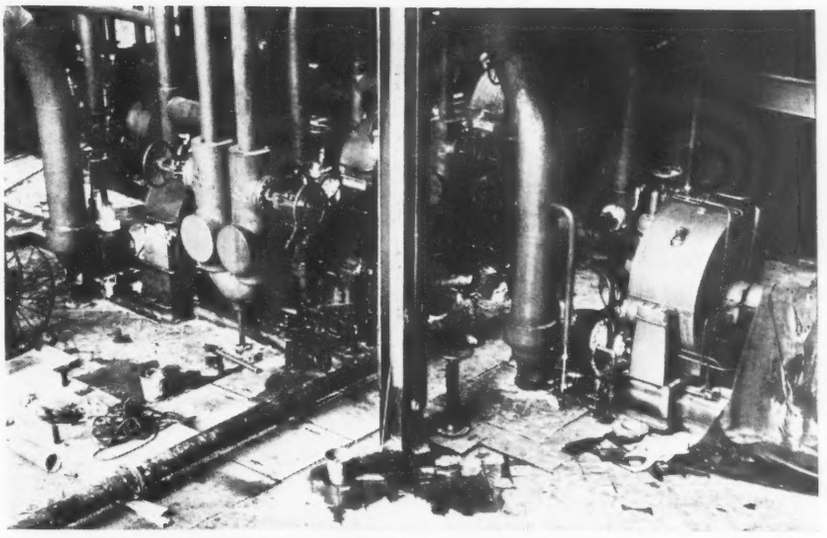
Before any estimate of damage to flooded distribution can be made, all cables and transformers, potheads, etc., in that area will have to be tested. As little of this has yet been done, it is not known when normal service will be restored.

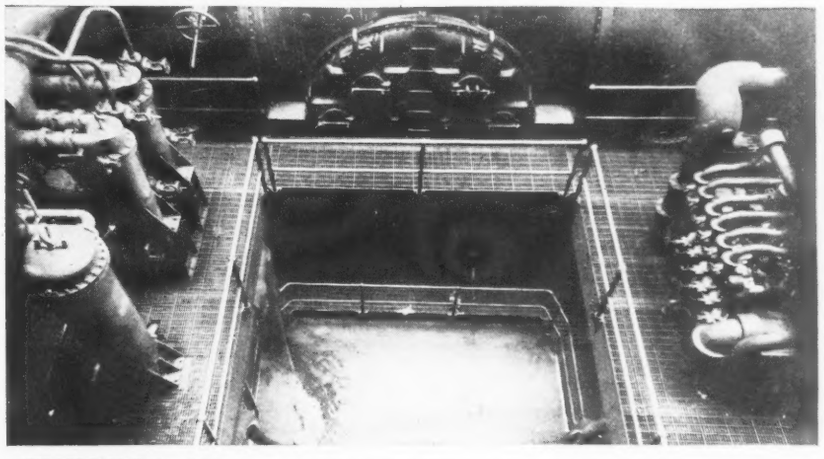
What has been accomplished toward restoring service has required heroic effort by all Duquesne men. Key men have slept in their offices, if at all, thereby being on call day and night. I am particularly grateful to E. A. Hester, T. E. Purcell and R. S. McCarty for having given enough of their valuable time to impart to me the information in this story and for the pictures they made available.

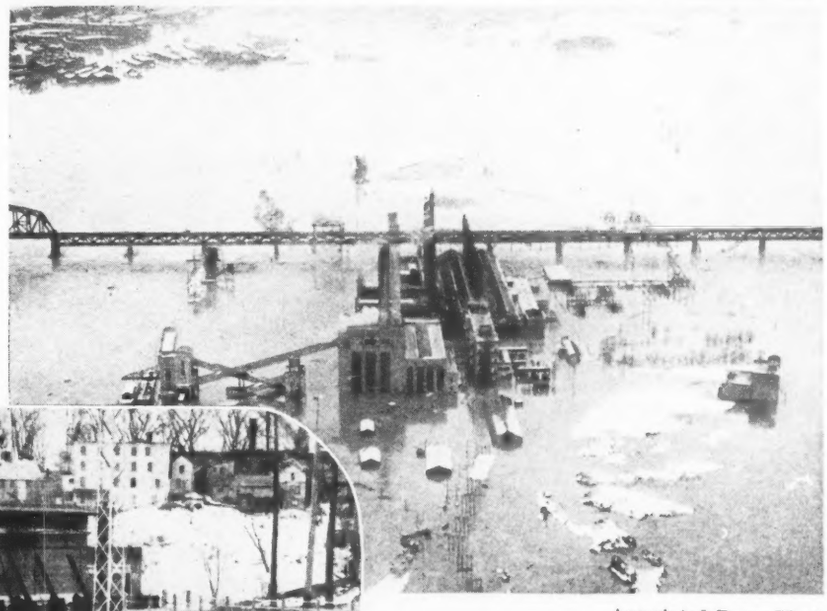
Other Flood Notes

Springdale Station of the West Penn Power Co. went out late Tuesday, March 17. More extensive interconnections and other stations on that system not affected by the flood prevented a system shutdown and per-

(Continued on news page 232)







Associated Press Photo

International News Photo

Middle—Looking down into the hotwell pit at J. H. Reed Station. About 6 ft. of water is still in it, although the water was at one time 2 ft. over the floor of the basement, shown at the center of this picture, and also in the top picture. One of the turbine-driven boiler-feed pumps used to pump water out of the hotwell pit is shown. Below it is the picture of the station and beside it Brunot's Island Station, both isolated by the flood. Left—Brunswick, Me., plant of Central Me. Power Co.

SPEAKING OF POWER

● Barnstorming about Europe certainly broadens the viewpoint but is hard on the constitution . . . I have been up almost with the dawn, inspecting plants, visiting with German, Swiss and other engineers, meeting and talking with foreign subscribers, then being entertained lavishly every evening. . . . Seven weeks of this and I'll be ready for a good long rest.

Aboard the *Europa,* I had a very agreeable session with Captain Scharf and another with Chief Engineer Eints. One thing that caught my eye on the bridge was a continuous recorder of the course—a pen record of how well the helmsman steers. . . . Such an enduring monument to man's skill, or lack of it, must be a great incentive to good work at the wheel, just as a record of CO_2 or air-steam ratio is an incentive to good furnace operation.

. . . to good work

The *Europa's* spotless engine room is nothing sensational in an engineering way, but it is a good, clean job throughout, with maintenance plus. . . . *Europa* is a 49,746-gross-ton quadruple screw liner with two streamlined stacks each 60 ft. deep fore and aft. Each screw is driven through reduction gears by a 3-cyl., 25,000-hp. turbine. Twenty double oil-fired water-tube boilers furnish steam at 310 lb. and 700 deg. Speed is 28 knots. Four 6-cyl., MAN diesel generating sets furnish lighting and power for the ship and its 23 elevators.

Aboard ship I pondered over a newspaper clipping that discusses the possible adaptation of steam-engine power for stratosphere flights. . . . When you stop to think of it, a steam engine (atmospheric exhaust) works better as you go higher because of lower back-pressure, while a gasoline or diesel engine gets out of breath unless supercharged. At very high altitudes the steam engine could operate with a fair "vacuum" while exhausting at atmospheric pressure to an air-cooled condenser, simply vented to the air without an air pump. Even such a radical departure as a submerged-combustion boiler might have possibilities. . . . The only thing that worries me (if I have any right to worry about an aviator's problems) is the boiler furnace. Thin air is almost as bad for a furnace as it is for a gasoline engine. . . . It would seem that the problem of supercharging is still present.

. . . steam

Word from New York tells me that this number of *Power* will include stories on two more "tops" for central stations. . . . The procession is growing to be a long one, what with orders for tops for Waterside, Millers Ford, Logan, 12th Street and several others, with new installations at Rochester and Cedar Rapids, and with the older ones at Kearny, Firestone, Goodyear, Ford, and others previously reported.

Alternating current celebrated its fiftieth birthday March 20. . . . It should be much older, judging by its growth. . . . Speaking of growth, a.c. had its first practical trial in March, 1886. Eight months later there was a commercial installation at Buffalo and a year and a half later there were between 30 and 40 installations. . . . A veritable man-made mushroom.

. . . man-made

Indulging ourselves a little in our fancy for queer, or at least unusual, power ideas, we are publishing on page 208 a short story on what its inventor calls a "kinetic" motor, really a rotary steam engine that lives up to that current popular song about "round and round" . . .

A few pages further on you'll see my first story on European power practice—a largely pictorial story of exhibits at the semi-annual Leipzig Fair. . . . Diesels and gas engines were all over the power section. . . . The German government is not only advocating convertible types for new installations, but also urging arrangements for conversion in present installations. . . . Germany must import most of her diesel fuel, hence has recently boosted the tax on it, but producer gas can be made from wood waste, brown coal or sawdust and chips, all of which are domestic products. So in case of stoppage of fuel imports, Germany wants to be ready. . . . It seems queer to me that, having turned to gas producers, Germany should not have done more toward their modernization. Several I saw were exactly like those we used many years ago in the United States.

. . . gas-producer

For many and many a year we've been hearing yarns that were good enough to tell, but we didn't have any place in the paper to tell them. . . . We're remedying that beginning with this issue by beginning a column called "Exhaust Lines," which Tangerman tells me is to include practical pointers as well as yarns. . . . He's on a still hunt for material, so if you have anything in mind, send it in. . . . This month I like particularly the story of the soot-blowing operation using a 2-quart bottle of gasoline. Somehow or other, I feel that that particular engineer may have suddenly stopped blowing soot that way—or even running a boiler plant—by the time this is written. . . . Verily, there must be a "Destiny which shapes our ends."

. . . soot-blowing

PHIL SWAIN
Editor

FLOOD DATA—*Power* will be glad to send free to any power engineer requesting it a special 6-page reprint on reconditioning power equipment affected by flood, as well as to publish helpful comments from readers.

SPRAY DOWN SOUTH

Progress is demanding more water for power, processes, air conditioning. When space is available, one way to keep water money from going "over the dam" is to use a spray pond. This one is at Industrial Cotton Mills, Rock Hill, S. C.

. . . for their most recent

Engineering Data

CELANESE CORPORATION
Cumberland, Md.

Capacity ....150,000 lbs./hour
Efficiency 85.5%
Pressure .....410 lbs.
Steam Temperature, future .....710° F
Fuel Burning Equipment
Riley Multiple Retort
Double Roll Clinker Grinder
17'6" Wide x 17'1¼" Long
Heating Recovery Equipment
Riley Header Type Economizer
Consulting Engineer: S. B. Roberts
Chief Engineer: F. T. Small

CELANESE CORPORATION, Cumberland, Md.
150,000 lb. RILEY STEAM GENERATING UNIT

installation of Boiler Equipment

Celanese also SWINGS to RILEY

Due to the rapid expansion of the Celanese Corporation in recent years, repeated additions have been necessary to their steam generating equipment. Celanese engineers have consequently had experience with a great diversity of steam generating equipment.

That the Celanese Corporation, in view of this wide experience, should have selected Riley Steam Generating Units for their most recent expansion is significant of the outstanding performance of Riley equipment in so many of the country's modern plants.

The excellent performance and complete satisfaction being obtained from the Riley unit at Celanese is further evidence of the faith which engineers can safely place in Riley equipment to more than fulfill its promise of outstanding performance. You can rely on Riley.

There has been a most significant and ever increasing swing to Riley Steam Generating Equipment. A swing of such magnitude that Riley sales have increased steadily since 1931 and to such an extent that Riley Boiler sales for 1935 were greater than sales of the boom year of 1929.

Be sure to consult Riley on problems involving modern efficient steam generating equipment

the SWING to RILEY increases steadily

A few typical sales of Riley Steam Generating Equipment in recent months

Lynn Gas & Electric Co.
Lynn, Mass.
1—205,000 lbs./hr. 430 lbs. - 810°F
Pulverized Coal Fired
Stone & Webster Engineering Corp. Engineers

Holyoke Water Power Co.
Holyoke, Mass.
1—200,000 lbs./hr. 675 lbs. - 750°F
Oil and Pulverized Coal Fired
Arthur T. Nelson, Engineer

Standard Oil Co. of California
Richmond, California
3—125,000 lbs./hr. 850 lbs. - 760°F
Stone & Webster Engineering Corp. Engineers

*West Virginia Pulp & Paper Co.
Williamsburg, Pa.
2—100,000 lbs./hr. 600 lbs. - 675°F

Socony-Vacuum Oil Co.
for Naples, Italy
2—60,000 lbs./hr. 750 lbs. - 700°F

Imperial Paper & Color Co.
Glens Falls, N. Y.
2—60,000 lbs./hr. 300 lbs.

Tsishuyen Electricity Works, China
1—110,000 lbs./hr. 233 lbs. - 680°F

*Large Chemical Plant
2—100,000 lbs./hr. 600 lbs. - 650°F

University of Minnesota
Minneapolis, Minn.
1—100,000 lbs./hr. 300 lbs.

Upper Michigan Power & Light Co.
Escanaba, Mich.
1—90,000 lbs./hr. 410 lbs. - 650°F
W. I. Barrows, Engineer

*Repeat orders.

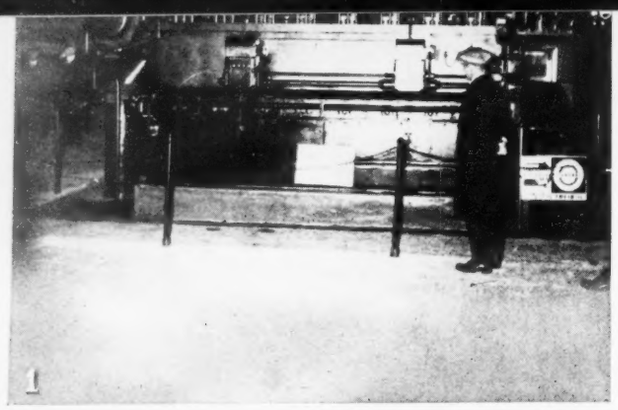
RILEY

STOKER CORPORATION, WORCESTER, MASS.

BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT TACOMA
ST. LOUIS CINCINNATI HOUSTON CHICAGO ST. PAUL KANSAS CITY LOS ANGELES ATLANTA

COMPLETE STEAM GENERATING UNITS

BOILERS - PULVERIZERS - BURNERS - STOKERS - SUPERHEATERS - AIR HEATERS
ECONOMIZERS - WATER COOLED FURNACES - STEEL-CLAD SETTINGS - FLUE GAS SCRUBBERS

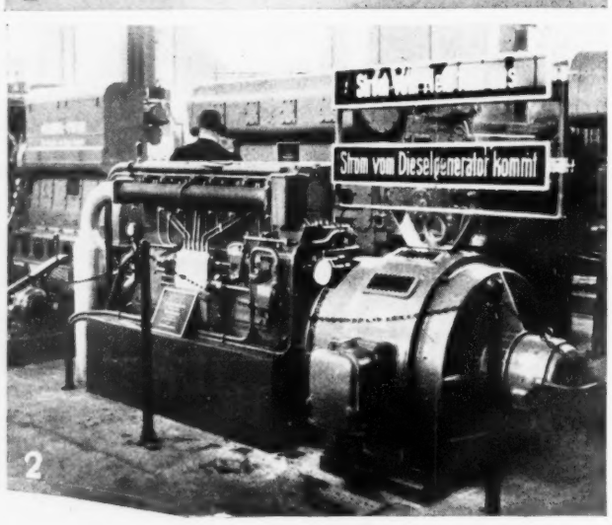


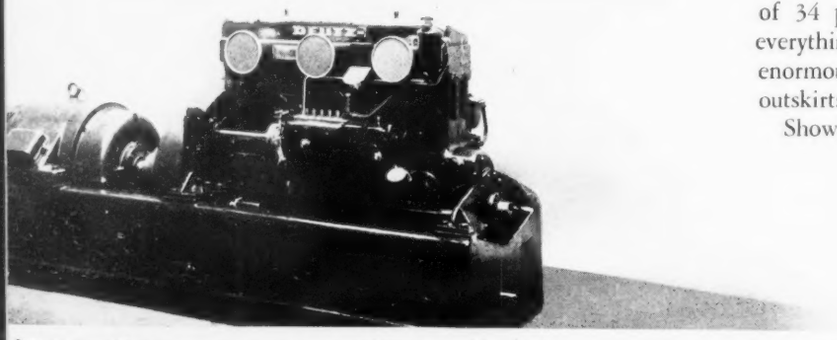
Acres of DIESELS at

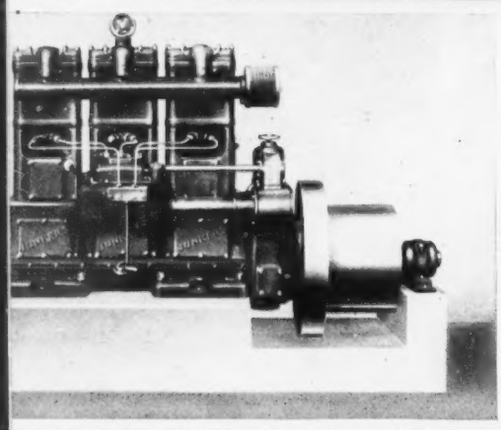
IN POWER circles, the "D" of Deutschland has long stood for "Diesels." Prof. Rudolph Diesel invented this neat and efficient prime mover back in 1892, other Germans by the thousand have contributed to its development. It was only to be expected then that diesels would dominate any power exhibit in Germany. Certainly they held all the front-row seats in the great building devoted to power equipment at the Leipzig Fair March 1-9. Nevertheless, a tendency to turn from diesels was evident—gas engines, as well as diesels quickly convertible to gas fuel were to be seen everywhere. Boilers, compressors, blowers, pumps, refrigerating machines, air-conditioning equipment were also shown in the Power Section.

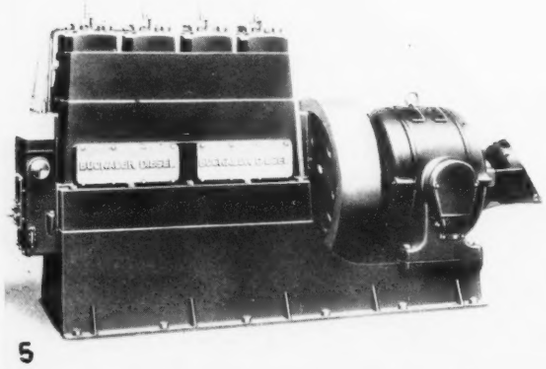
The Fair is held twice a year in Leipzig, ancient city in Saxony close to Dresden and about 100 miles southwest of Berlin, and has been held for 700 years! This Fair is No. 1975. Nearly 250,000 visitors flocked into the 750,000-person city this time, not only from Germany but from all corners of the globe. Great crowds filled streets, packed hotels and mopped up every spare room in private homes for miles around. The Fair is really a group of fairs, consisting of 34 permanent buildings in the city proper devoted to everything from musical instruments to Dresden china, and 18 enormous exhibition halls in the technical fair section on the outskirts of the city.

Shown in the lot devoted to construction machinery is that

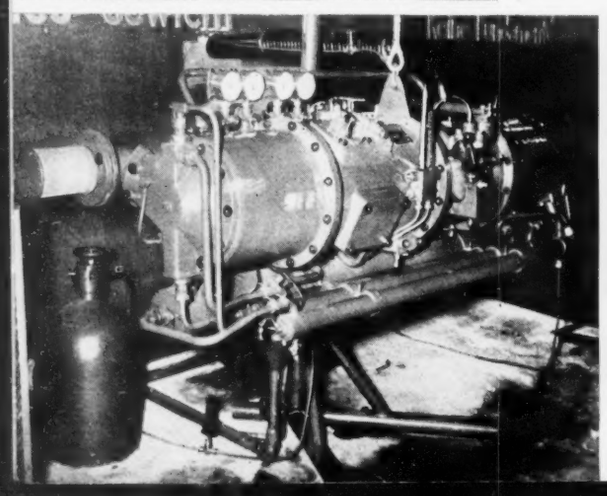


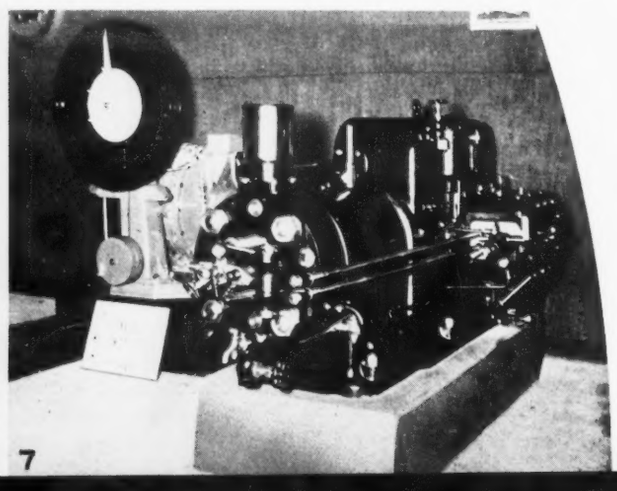






1—800-hp., 8-cyl., 4-cycle Deutz diesel with supercharging blower driven by an exhaust-gas turbine. 2—MAN 100-kw. emergency diesel set starts itself and comes up to speed in 6 sec. (timed by my own watch) by compressed air through an electro-magnetic starting valve. 3—Deutz 112-hp., 1,500-r.p.m., 4-cycle alternator set. 4—75-hp. Junkers diesel, shown at the Fair on a spring mounting. 5—Buckauer 120-hp., 4-cyl. alternator set. 6—Junkers opposed free-piston diesel air compressor running at full speed hanging only from a central cable, with a pencil balanced on it. 7—LHW 40-hp., 650-r.p.m., medium-size, horizontal diesel coupled to a Junkers water brake





By Philip W. Swain

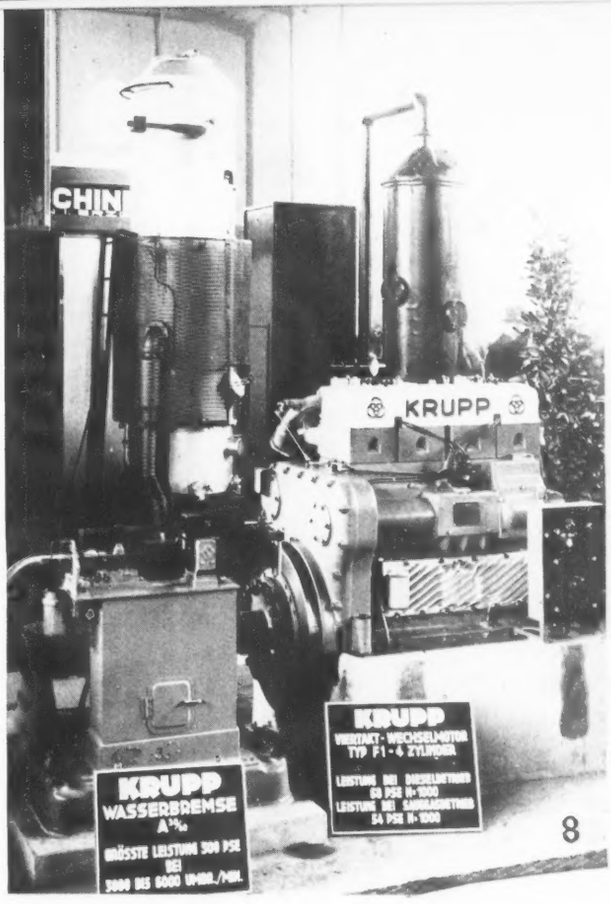
Editor of POWER

the Leipzig Fair

queer "Frogrammer" we mentioned recently, a gasoline-driven half-ton tamper that jumps up and down guided only by two small handles. Another strange device is a diesel pile driver. Its stationary piston projects upward from the steel block that rests on the head of the pile being driven. A 1-ton block containing the cylinder moves in guides. This block is hoisted about 5 ft. (top limit of its travel) by hand, then dropped onto the piston, trapping and compressing air in the cylinder. At the bottom of the stroke, oil sprays from a nozzle in the piston head and burns just as it does in a diesel, tossing the cylinder block back up in the air for the next stroke.

Most diesel builders featured convertible engines, principal conversion methods being blocking up the crankshaft, inserting filler pieces at crankpin end of connecting rods, changing cylinder head, changing piston or top of piston. The shift from diesel to gas generally cuts capacity about 8%, varying of course with the richness of the gas used.

In MAN's 16-engine exhibit was a 170-hp. weather-proofed power unit on welded-steel skids. It is a convertible, 4-cycle, 5-cyl., 500-r.p.m. unit with valve mechanism housed in a latched-cover steel cabinet to avoid trouble from moisture. A double grid of copper tubing cools lube oil in front of the water-cooling radiator. MAN also showed a 12-cyl. V-type, 1,400-r.p.m. machine with a single crankshaft with six crankpins, supercharged and driving a d.c. generator.



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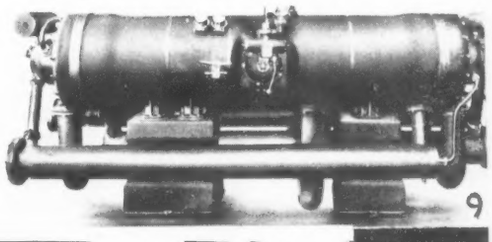
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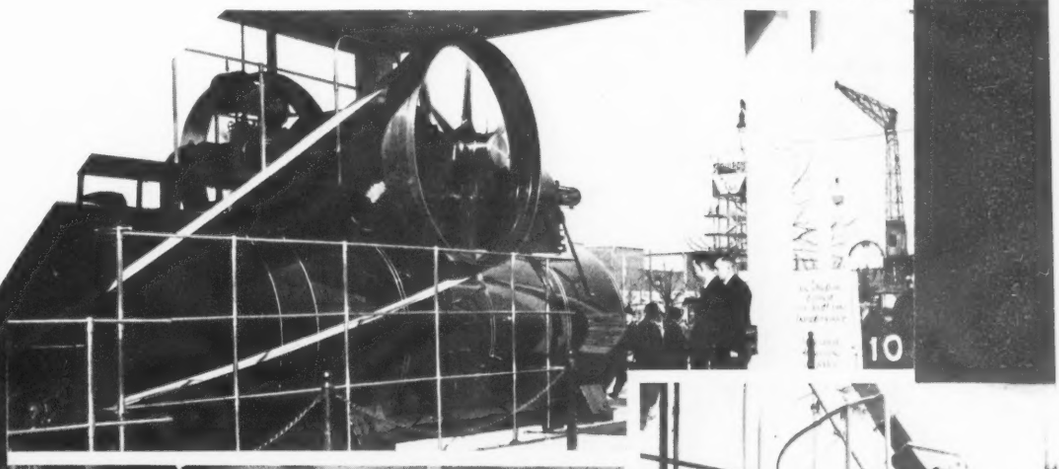
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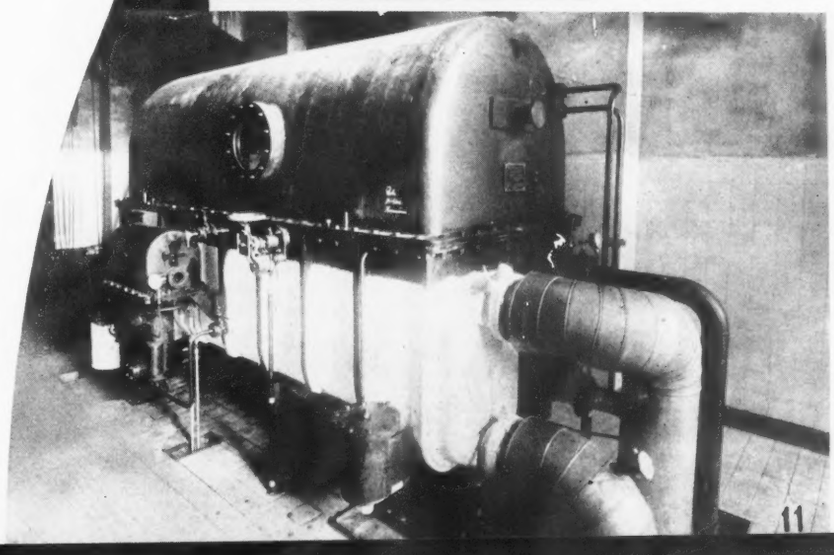
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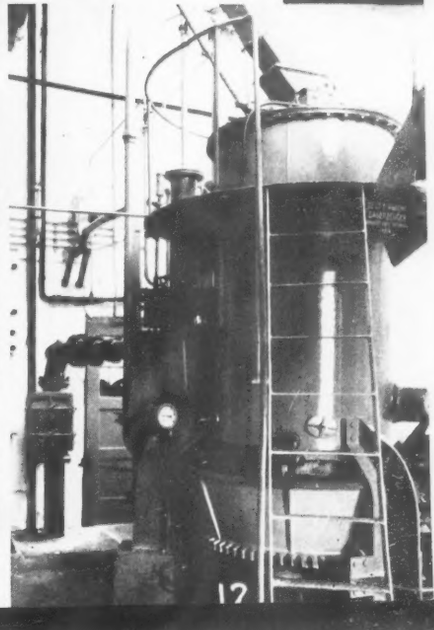
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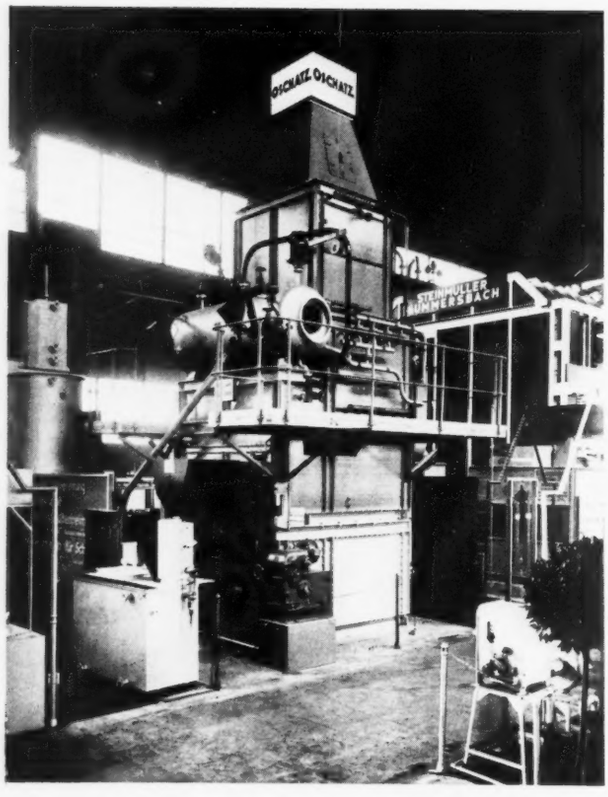
8—Krupp 1,000-r.p.m., convertible engine-generator giving 68 hp. as a diesel and 54 as a gas engine powered by gas from the producer behind it. 9—Junkers 12-cu. meter per min., free-piston compressor delivers air at 85 lb. pressure. 10—Woolf Locomobile steam engine, mounted atop its boiler. 11—Brown Boveri showed this hermetically sealed refrigerating plant, with compressor, condenser, evaporator and motor completely enclosed. The motor runs in the refrigerant. Units up to 2,670 tons of refrigeration are of this type. 12—Deutz anthracite-gas producer, shown driving a gas engine at the Fair



LaMont boiler, which uses forced circulation to get high heat transfer. The desired distribution of water to tubes is controlled by orifices at tube entrances with provision to prevent clogging. Shown by Dampf. F. L. Oschatz

Units of this type are being used on the "Flying Hamburger" and other fast trains.

Junkers Motorenbau showed a 5 to 6-hp. opposed-piston diesel running at 1,500 r.p.m. and a 75-hp. 3-cyl., vertical, opposed-piston unit running at 750 r.p.m. on a spring mounting so soft that the entire machine swayed about half an inch when I jumped on the platform. Without foundation, this engine weighs 5,700 lb.

Even more interesting to me were the free-piston diesel air compressors of Forchungs Anstalt Prof. Junkers, so smooth that I could have the time exposure of Fig. 5 made while the 4-stage unit (3,000 to 4,000 lb. per sq.in. pressure) was running at full speed! All moving masses cancel—each moving piston is double, diesel at the inner end, compressor at the outer, and they bounce freely in and out between the air cushions. With stepped pistons, any number of stages can be used without increasing the number of pistons. Cost is said to be about 70% that of a diesel-driven air compressor. Pistons are racked out by hand to start, then allowed to snap together to ignite the diesel charge. Machines on display ranged from 2.2 to 15 cu. meters of free air per min., 1 to 4 stages, 35 to 50 hp., and 85 to 4,000 lb. discharge pressures. Fixed masses and elastic forces cause the machine to maintain its speed automatically, varying but little with load. The units will even run at no load due to air locked in the compressor end. Falling air pressure in the discharge receiver increases the amount of fuel oil injected, which in turn lengthens the power stroke and compresses more air, a simple governing system if there ever was one!

Krupp, known to every American who fought in the World War, showed a 4-cycle, 4-cyl., vertical engine running at 428 r.p.m. A lobed-type positive, mechanically driven supercharging blower increases power from 270 to 375 hp. LHW showed some small hopper-cooled horizontal diesels, Buckauer showed eight samples of its valveless engines, ranging from a 1-cyl. 725-r.p.m., 12-hp. unit to a 4-cyl., 600-r.p.m., 120-hp. unit.

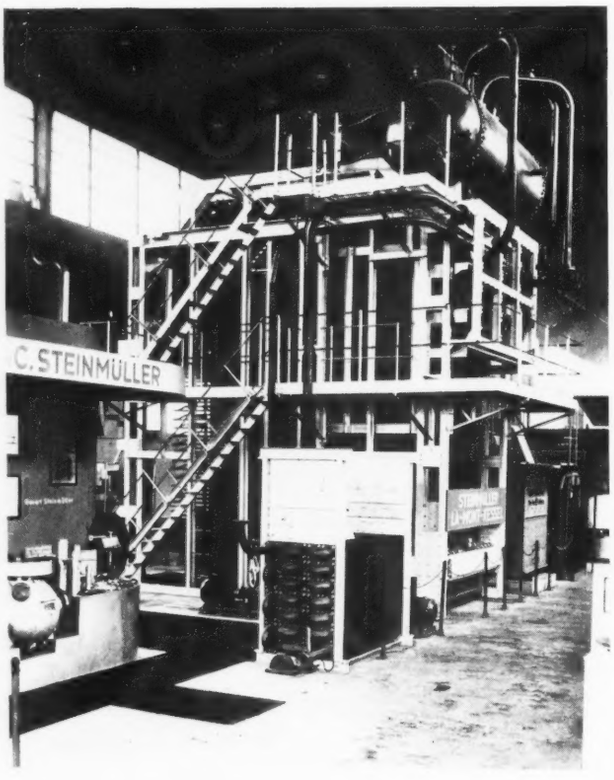
Christoph shows a number of 1-cyl. horizontals, all convertible, and ranging from an 8-hp., 1,000-r.p.m. to a 60-hp. unit. Conversion is made by blocking the crankshaft and exchanging the spark plug for a fuel valve. This company also showed a gas producer fired with sawdust and chips, explaining to me that many small German woodworking plants frequently operate alternately on diesel and gas, burning diesel oil until enough sawdust and chips are available for an economical period of operation as gas engines. These producers were the suction type, as were those of Deutsche Werke. The latter company had wood producers which were simply tall refractory-lined cylinders, hand fired through a trap at the top and with ashes dumped by hand to a water-sealed pit. The coal-fired producer, however, has a mechanical drive.

Deutz also gives particular attention to gas and convertible engines. MWM showed 17 engines, nine of them in operation!

One of the most interesting diesel test gadgets was the Zeiss piezo-electric indicator which indicates the pressure-volume relation in the cylinder of a high-speed diesel by a fast-moving light beam through a special crystal and electric amplifier. The diagram can be seen on a screen or picked up by camera, but the price is quite high—3770 marks.

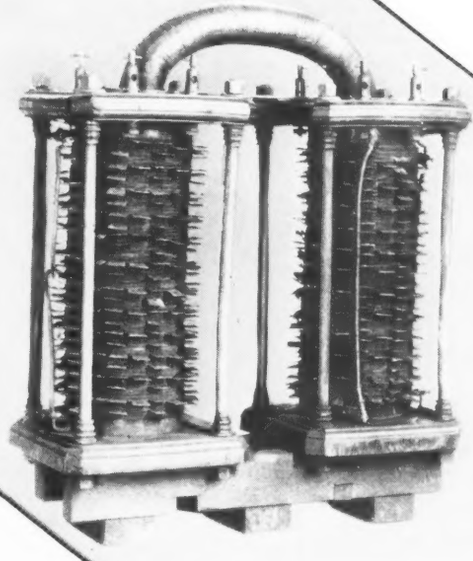
This story is tarred and feathered with diesels for the simple reason that the Fair itself ran that way. Of the outstanding power exhibits in other lines, I have chosen the most interesting for illustrations. Judging by the Fair alone, one might gather that they don't work with steam turbines in Germany. This impression will be dispelled, I hope, by a separate story I have written of the very impressive turbine developments in the A.E.G. factory in Berlin.

Another LaMont boiler, this one shown by L. & C. Steinmuller. About 8 times as much water is circulated as is evaporated. This increases heat transfer and insures against tube burnouts



A.C. TURNS 50

George Westinghouse, who backed Stanley in the development of alternating-current systems, and below, the Gaulard & Gibbs induction coil he brought to the United States in 1885, from which Stanley developed the transformer

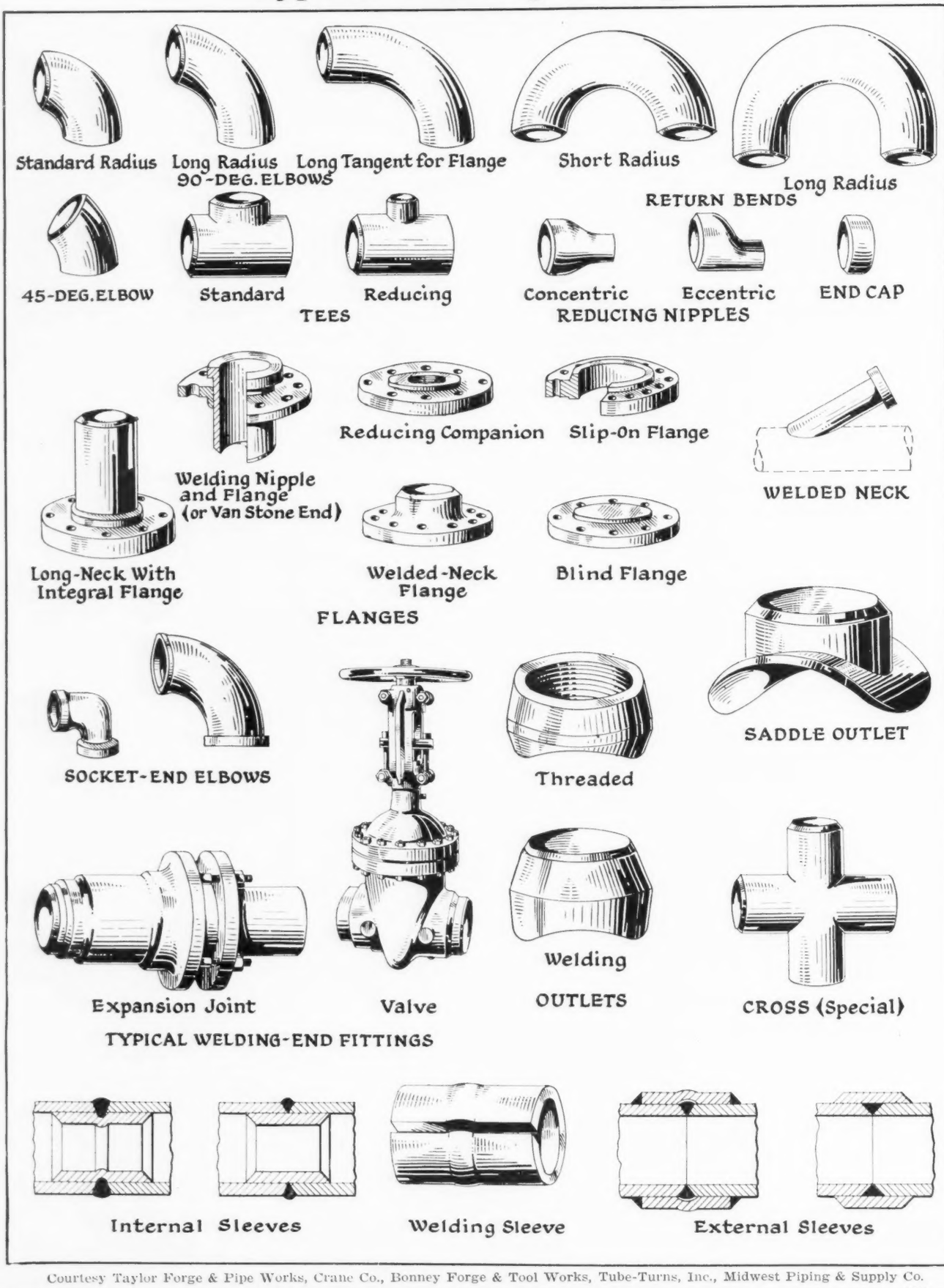


William Stanley, pioneer engineer, who successfully demonstrated the first U. S. a.-c. system, and above, one of the 16-pole a.-c. generators designed for the first commercial station at Buffalo, Nov. 30, 1886

Successful demonstration of the first alternating-current system at Great Barrington, Mass., March 20, 1886, initiated modern power systerms and universal use of electricity. George Westinghouse bought American rights to a proposed, but impractical, system; William Stanley's intensive work developed a practical transformer and transformer system. 1½ years later more than thirty plants were in operation

Number 43

Typical Welding Fittings



Courtesy Taylor Forge & Pipe Works, Crane Co., Bonney Forge & Tool Works, Tube-Turns, Inc., Midwest Piping & Supply Co.

© POWER

THE ENGINEER'S BOOKSHELF

Oliver Evans

OLIVER EVANS, A CHRONICLE OF EARLY AMERICAN ENGINEERING (1935)—*By Greville Bathe and Dorothy Bathe. Published by the Historical Society of Pennsylvania, Philadelphia. 362 pages, 9x11 in. Index. Cloth. Price $15.*

The year that Oliver Evans was born, the first engine using steam was set to work in America. Josiah Hornblower brought it over, then stayed here to operate it. But it was Oliver Evans who improved upon these simple atmospheric engines. American father of high pressures, he also worked with boiler accessories, compound engines, an illuminating-gas generator, and improved then-known processes of milling and turning. Unfortunately, biographers of his time thought him only a constant litigant, for as was many another inventor of his time, he was constantly engaged in lawsuits to protect his rights. These and the need for ready cash forced him to turn from his original idea of developing the high-pressure engine for locomotives, so that it was someone else who eventually adapted it to motive power.

To correct many false impressions about Oliver Evans, and to give him his just due as an important contributor to the engineering advancement of his country, these authors have made an exhaustive study of source material, utilizing only that of proven authenticity. The result is an immensely valuable work on one of the high-pressure pioneers.

Data on Fuels

TECHNICAL DATA OF FUELS *4th edition.* (1936). *Edited by H. M. Spiers, published by The British National Committee, World Power Companies, 36 Kingsway, London, W. C. 2, England. 358 pages, 5x7½ in. Cloth. Charts and tables. No price given.*

This handbook, now in its fourth edition, contains much valuable data on subjects other than just fuels. For example, data are given on properties of air, water and gas, specific heats, thermodynamic properties of materials, thermal conductivity and heat transfer, metals and alloys and refractories. A leading characteristic of the book is its conciseness. About 70 pages of new material have been added.

Technical History

A HISTORY OF SCIENCES, TECHNOLOGY AND PHILOSOPHY (1935)—*By Prof. A. Wolf, University of London. Published by the Macmillan Company, 60 Fifth Ave., New York, N. Y. 675 pages, 6½x10 in. Index. 312 illustrations. Cloth. Price $7.*

With the fall of the Egyptian and Roman civilizations, science passed into the discard, not to be heard of again for over a thousand years. But in 1543, Copernicus published the heliocentric theory, and the parade of progress began again, with the astronomers—Galilei, Tycho Brahe, Kepler, Newton—leading the way. Advances came in every field, with such men as Huygens, Römer, Halley, Torricelli, Wren, Descartes, Gilbert, Boyle, Hooke, Spinoza, Hobbes, and many another like them ever in the van. Discovery piled upon discovery, and the Dark Ages were no more.

It is of this period that Professor Wolf writes. The breadth of coverage of the book is unusual, as are its meticulous attention to detail and ready readability. If you enjoy browsing in well-written history for your "serious entertainment," this is a fascinating book, scolarly, yet amazingly simple. If your interests are purely on power subjects, then there are chapters on scientific instruments, mathematics, mechanics, physics, light, heat, sound, magnetism, electricity, chemistry, mechanical engineering, and the steam engine. It discusses these things from their rebeginning through the "century of genius."

Engineering Math

MATHEMATICS OF MODERN ENGINEERING, VOL. I (1936)—*By Robert E. Doherty, dean of the School of Engineer, Yale University, and Ernest G. Keller, associate professor of applied mathematics, University of Texas. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 314 pages, 6x9 in. Price $3.50.*

Based on an advanced course given by General Electric to its apprentice engineers, this text is intended for a 2-year course extending into post-graduate study. Its approach is eminently practical, and methods described have been tested in practice and found sound. Instead of the usual theoretical attack, here a scientific appoach is made to a problem, including statement of the problem, required accuracy, time available for solution, necessary assumptions, translating into mathematical form, and interpretation of results. Mathematics included is that of practical use to mechanical and electrical engineers.

English Handbook

KEMPE'S ENGINEER'S YEAR-BOOK, 1936 *(42nd annual edition)—Revised under direction of L. St. L. Pendred, editor of "The Engineer," London. Published by Morgan Brothers, Ltd., 28 Essex St., Strand, London W.C.2, England. 2664 pages, 5x7¼ in. Partly thumb indexed. Flexible covers. Price 31/6d net.*

Dealing with all phases of modern engineering practice, this handbook is about twice the thickness of familiar specialized handbooks and is much more general in included data. A new section dealing with acoustics, noise and vibration has been added this year, as well as a number of additions to the sections on steam and electric power engineering. Among strictly power engineering subjects included are articles on heat insulation, refractories and cements, water power, hydraulics, thermodynamics, steam engineering, internal-combustion engines, electrical engineering, power transmission gas and gas-works, heating and air conditioning, air compression, etc. This book also includes a trade descriptive section which gives detailed data on products of many British engineering firms. Includes Buyer's Guide.

BRIEF REVIEWS

AMERICAN LUBRICATING GREASES (1936). *By James I. Clower, Asst. Prof. of Machine Design. Published by Virginia Polytechnic Institute, Blacksburg, Va., as Bulletin No. 35. 80 pages, 6x9 in., 23 illustrations, 13 tables. No price given.*—Information concerning composition, manufacture, uses and testing of lubricating greases is given in brief, non-technical wording from point of view of user rather than manufacturer. 9x22-in. chart on classification, composition, and use of greases, tipped-in on back cover.

REPORT OF SMOKE ABATEMENT LEAGUE OF HAMILTON COUNTY FOR 1935 (1936). *By Frank H. Lamping, Supervisor, 2901 Union Central Bldg., Cincinnati, Ohio. 10 mimeographed 8½x11-in. pages. No price given.*—Annual report of Cincinnati, Ohio, Smoke Abatement League.

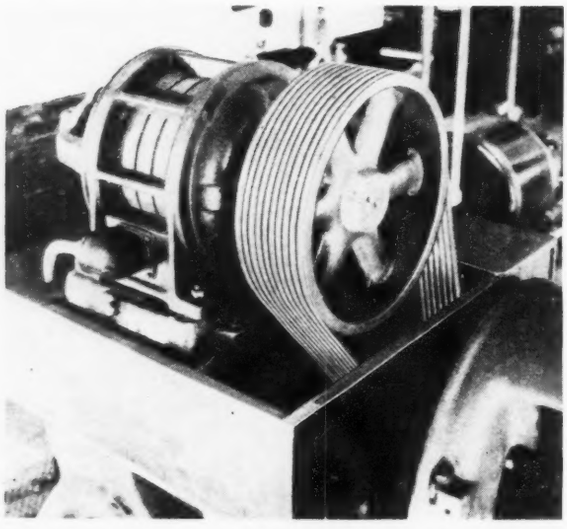
LEFAX SHEETS (1936). *Published by Lefax, Inc., Philadelphia, Pa. Three 4-page folders, No. 35-55, on Painting of Steam and Hot Water Radiators; No. 35-59 on Lead Pipe Sizes and Weights and No. 35-66 on Wire Gages.*

TREND OF BOILER DESIGN (1936). *By Perry Cassidy. Published by Babcock & Wilcox Co., 85 Liberty St., New York, N. Y., as Bulletin 3-180. Free.*—Reprint of paper presented before the Engineers Society of Western Pennsylvania and Pittsburgh Section of A.S.M.E., October, 1935. Shows how factors internal to boiler affect trend of boiler design. Large amount of valuable data is given in form of curves, such as heat absorbed by boiler tubes at various radiating temperatures, required thickness of boiler tubes, temperature drop through walls of boiler tubes, temperature drop through boiler scale. Data is given for superheater design, holding power of expanded tubes, drum design, economizer tubes and some excellent advice on boiler water treatment.

RUBBER PLANTATION IN NEW JERSEY (1936). *Published by Thiokol Corp., Yardville, N. J. 40 pages, cloth, black and white sketches. No price given.*—Brief story of developments in utilization of synthetic rubber by American industry. Non-technical.

BRUSHES (CARBON, GRAPHITE AND METAL-GRAPHITE) AND BRUSH SHUNTS (1936). *Published by U. S. Department of Commerce, National Bureau of Standards. Simplified Practice Recommendation R56-35. Available from Superintendent of Documents, Government Printing Office, Washington, D. C. 24 pages, 6x9 in. Paper. Many diagrams and tables. Price, 5 cents.*—Simplified Practice Recommendation superseding R56-28.

PRACTICAL AIDS TO OPERATION



Multiple V-Belt Starts Synchronous Condenser

AT BRATLESVILLE plant of the Public Service Company of Oklahoma, Tulsa, Okla., it was desirable to install a synchronous condenser for power-factor correction and voltage regulation. To provide the reactive capacity a 750-kva., 3,600-r.p.m. turbine-generator was moved to the Bratlesville plant from another station. As the generator capacity was not needed at the plant, the steam condensing and other auxiliaries were not installed. The turbine shaft and disks were removed and a dummy shaft installed to prevent the losses due to windage of the turbine rotor.

A 35-hp., 1,200-r.p.m. wound-rotor motor brings the generator up to speed for synchronizing before connecting it to the power system, and thus reduces starting-current peaks. This motor is connected to the generator by a multiple V-belt, as in the photo. Because of the high speed of the generator it was necessary to use an unusually high belt speed of 7,400 ft. per min. To insure satisfactory operation of the drive at this speed, the sheaves were dynamically balanced by the manufacturer. As soon as the generator is up to speed and synchronized with the power system, the motor is disconnected and it and the belts run idle. The drive has now been operating for nearly three years without complaint.

Load conditions at the plant are such that frequently operation of the synchronous condenser makes it unnecessary to run a large generating unit. This results in considerable improvement in plant economy.

Denver, Colo. M. NASBY
The Gates Rubber Co.

Corrected Faulty Commutation With Paper Shim

A LARGE percentage of d.c. motors, especially those using 500 volts, show the effects of faulty commutation. A simple method of correcting this fault on one machine may be of interest to those who have similar trouble.

Five years ago, a motor then about 25 yr. old was included in an inspection-service contract by which the owner was furnished a report, with recommendations, on any conditions found requiring attention. On the first inspection the commutator surface was found to be burned at several places.

Regardless of the cause, turning the commutator was advisable, and recommendations made accordingly. Instead of removing the armature for turning in a lathe, a commutator stone was used and a very satisfactory result obtained. But, in spite of the most accurate spacing and alignment of brushes, burning would develop, making it necessary to repeat stoning every three or four months.

Due to a change of responsibility in maintenance of this motor about two years ago, further effort was made by the inspector to correct this troublesome condition. For a time it appeared that new brushes would solve the problem, although the necessity for new brushes could not be determined. After two or three months, it became evident that the trouble still existed. Not being willing to accept the idea that the trouble was unavoidable, as frequently advised by experienced mechanics, this service inspector continued his efforts to locate the fault.

It was found that there is 0.006-in. clearance between brushes and brush-holders. Paper of about this thickness was used to shim the brush in the holders, preventing nearly all brush movement due to reversing armature rotation. In that experiment, the trouble was located. Without any other change, this commutator has taken on a polish that only correct commutation produces.

Wichita, Kansas JOHN F. WOOLEY

Is Saving High-Pressure Drips Economical?

INCREASING popularity of higher steam pressures and temperatures as a means of improving industrial power-plant economy has created a number of design problems. Among these, the question of high-pressure drip disposal requires considerable thought. In all too many instances, attempts to recover the discharge of high-pressure traps prove uneconomical. Service required of traps draining low points of high-pressure superheated steam lines consists mainly of removing condensation during warming-up periods or when the line is dead-ended. They also assist in removing water carried over with steam from the boiler in such a manner that its evaporation in the superheater or by desuperheating the steam does not occur before the drip point is reached.

Observation of trap discharge frequency under normal operating conditions will usually reveal that no discharge occurs except occasional action to remove condensation formed within the trap itself and its connections. Heat loss from the trap body and its connecting lines can be minimized by adequate insulation. Recovering condensation from such traps will largely depend on the service factor of the high-pressure steam line being drained. With the line dead-ended a considerable part of the time, recovery of trap discharge may be economical. In the great majority of cases, however, power-plant performance will be bettered by wasting this condensation.

High-pressure drip economics amounts to more than bal-

ancing the value of condensation heat and water recovered against cost of piping to effect its recovery. Heat balance losses which would occur, should the trap leak or lose its prime, and cause displacement of exhaust or bled steam by high-pressure steam, must also be considered. Unless the trap return line is continuously checked for evidence of leakage, a chore often neglected, losses from this source may soon nullify the savings from return of normal trap discharge. Where drips are wasted, the discharge should be visible so that any sign of leakage may be immediately detected and corrected.

Lynchburg, Va. O. M. ROBERTS

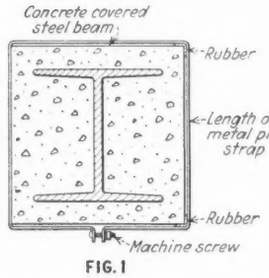


FIG. 1

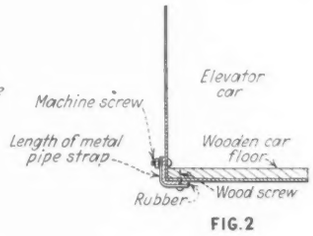


FIG. 2

Protects Control Cables With Rubber Hose

IN ONE building, trouble developed because the exterior covering on the elevator control cables was wearing by coming in contact with concrete beams between the hoistways and around the corners of the cars. To remedy this, I put lengths of 1-in. rubber hose (cut open) over the two corners of the beams nearest the cables, as in Fig. 1. These rubber strips are held in place by metal straps as shown. To protect the cables at the corners of the cars, lengths of rubber hose cut open were applied as in Fig. 2.

Baltimore, Md. THOMAS TRAIL

Cause of Bulges in Internally Fired Boilers

BULGING of furnace sheets of internally fired boilers is often dangerous and practically always an indication of neglectful or incompetent operation. All common types of internally fired boilers except the Scotch have a water-leg and crown sheet. This water-leg makes a natural pocket for sediment and loose scale.

As long as this accumulation is below the grate line, the most serious results likely are retarded circulation and possible accelerated corrosive action. However, when the accumulation builds up above the grate line, which often happens, serious overheating and bulging of the furnace sheet will occur. More serious cases have caused the furnace sheet to tear away from the staybolts, and an explosion results.

Crown-sheet failures, other than those caused by corrosion, are usually preceded by bulging. These failures generally occur in locomotive-type boilers. They are most often caused by an accumulation of scale, oil, or sediment. Overheating, bulging, and rupture are usual results. Low water will also cause such a failure.

Preventive measures include frequent blowdown of the boiler and periodic removal of lower handhole plates for boiler washouts. Frequency of washouts is determined by the concentration of solids in the water.

Crown-sheet failures from scale and sediment accumulations may be prevented by keeping boiler-water concentration at low value. This is done by frequent blowdowns. The handhole plate in the front head should be removed at frequent intervals to inspect the crown sheet for any accumulations of scale or sediment on the water side, which should not be allowed to reach any appreciable thickness. These precautions and a boiler feedwater supply having as low concentration as possible will do much to reduce likelihood of trouble from this source.

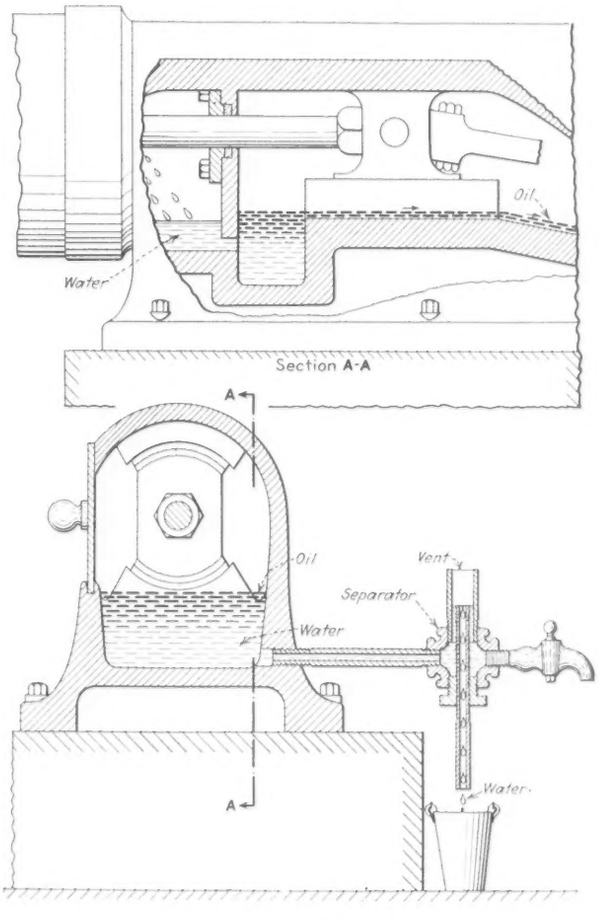
Cleveland, O. CHAS. A. ARMSTRONG

Automatic Drain Prevents Engine Oil Emulsifying

RECENTLY I had occasion to put into service a steam engine that had stood idle for several years. I found that the well between the crosshead guides and the cylinder was piped back into the crankcase and that in a short time the crankcase oil would emulsify. Evidently water was draining back from piston-rod drips into the crankcase.

To eliminate this difficulty I took out the connection between the crosshead well and the crankcase. The crankcase was plugged, and into the crosshead well an oil and water separator was installed as in the figures. This separator automatically drains off the water collecting in the well from piston-rod drips, and the oil flows back to the crankcase along the side of the crosshead guide shoes. The drain nozzle has a running thread so it can be adjusted to keep the water at any desired level in the well.

Cincinnati, O. ANTHONY A. FETTE
Chief Engineer,
Cincinnati General Hospital



CURRENT COMMENT

Special Gas-Washing Plant For Battersea Station

MY ATTENTION has been directed to the paragraph headed "Thou Shalt Not Smoke" on page 14 of your January issue, wherein it is stated that the Howden I.C.I. system for flue-gas washing has been installed at the Battersea Power Station. I would state that the particular installation in use at Battersea—the first gas-washing plant of any magnitude—is a system which has been developed and patented by London Power Company Limited.

London, England SIR LEONARD PEARCE,
Engineer-in-Chief,
London Power Co., Ltd.

(The complete Battersea gas-washing installation was described in *Power* on pages 490 and 491 in September, 1933. On pages 426 and 427 of *Power* for August, 1935, the Howden I.C.I. system is described. In this latter article it is explained that the Howden system has been in use for two years experimentally on one boiler of the Billingham-on-Tees plant of Imperial Chemical Industries, Ltd., London, and that it is to be used in Fulham (London) and the second section of Tir John (Swansea) stations, now under construction. However, a later article by David Brownlie, pages 645 and 646 of *Power,* December, 1935, explains that Tir John's flue-gas washing plant is to be "essentially similar to the installation at Battersea," and it was from this reference that the erroneous statement corrected by Sir Leonard Pearce was taken.—*Editor*).

Cause of Flarebacks on Low Loads

BASING my conclusions on experience in our own plant with a 16,500-sq.ft. pulverized-fuel-fired boiler, I would say that the cause of the flarebacks mentioned in January *Power,* page 43, is too-coarse pulverization. This may be due to any of three factors or a combination of them: Poor condition of the hammers on the latter stages of the pulverizers, too much carrier air, or intermittent feeding.

Our boiler is equipped with six horizontal burners of the turbulent type, four supplied with coal by unit impact mills (2 burners per mill), the other two by a mill of a different type.

Owing to the particular design of the feeder on the impact mills, we have difficulty in maintaining uniform feed to the mill. This in turn gives varying degrees of fineness and intermittently rich and lean mixtures to the burners. The fire is puffy and calls for considerable attention on the part of the operators, particularly at light loads when one mill is running alone and supplying about 4,500 lb. of coal an hour to the furnace.

With the other type of mill, close adjustment of coal feed is possible and the carrier air can be controlled to give a fineness of 87% through a 200-mesh screen. This gives an almost perfect fire, and we can operate two burners on the lightest load with this mill, which is impossible with the impact type owing to the coarser pulverization.

About two years ago, a photo-electric-cell-controlled oil valve was installed on the furnace to admit a jet of oil to sustain an ignition flame in the furnace, should the fire go out. This was done to lessen or obviate the dangers incident to flarebacks, stoppages in feed, etc.

Winnipeg, Man. C. L. ALEXANDER

Big 3,600-r.p.m. Turbines in 1930

I HAVE just read with much interest your article entitled "15 Years" in the Mid-December, 1935, issue of *Power.* I note on Page 689 the following paragraph on the second part of the page:

"Back in 1920, large turbines never ran faster than 1,800 r.p.m. In 1935, several 3,600-r.p.m. machines were built for capacities as high as 10,000 kw."

It has occurred to me you will be interested to know that during 1929 C. A. Parsons & Co. Ltd., Newcastle-on-Tyne, England, were manufacturing a 15,000-kw. (18,750 kva.), single-cylinder, 3,600-r.p.m. condensing steam turbo-alternator. This machine was designed for 350 lb. gage, 725 deg. F., vacuum 29 in. (Bar. 30 in.).

This turbo-alternator unit complete with condenser was ordered by the City of Regina, Sask., Canada, and was installed and put into commercial operation about June, 1930. At the time of installation, this machine was certainly the largest 3,600-r.p.m. single-cylinder condensing unit in the world. To this day, I believe it still may claim this distinction. Since going into commercial operation almost six years ago, I understand it has operated without trouble.

As a constant reader of your publication, may I congratulate you on the many interesting articles which are consistently brought to the attention of engineers.

Toronto, Ont. A. G. M. BROWN

Flat Vs. Curved Bridge Walls

THE discussion overheard by Bunyan Kennedy, and printed in the February *Power* is interesting and a typical example of the contrast between combustion 25 yr. ago and that of today. Present improvements in design were not made hit-or-miss, but by sound calculations proven in practice.

Before directly answering the question of whether a horizontal bridge wall or one shaped to boiler-shell curvature and but 8 in. from it should be used, it might be well to answer the question: Why a bridge wall? Primarily, the bridge wall supports grate bars at their rear ends and prevents fuel falling into the combustion chamber when working the fires. To deflect the hot gases upwards towards the boiler shell is a secondary purpose.

The point mentioned by Mr. Kennedy of the "flames hugging the boiler" is known as flame scrubbing, or impingement. In the first place, such a localization of heat is dangerous, and may bulge the boiler if a slight amount of sediment or scale lodges inside the shell. Secondly, it tends to reduce the gas temperature below the ignition point before combustion is completed. Under such conditions, a flue-gas analysis would show low CO_2, appreciable CO and excess oxygen. This condition shows oxygen to spare, but yet it did not unite with the carbon monoxide (CO) for complete combustion. Turbulent mixing of products of combustion at high temperatures is necessary for efficient combustion.

A third point which has been proved by test is the value of boiler surfaces exposed to direct radiant heat of the fire. Heat of the fire and products of combustion is transmitted to the boiler surfaces by either radiant heat or by convection from the hot gases. A lower bridge wall allows a greater length of the boiler shell to be exposed for radiant heat absorption. This is conducive to efficient boiler operation.

A good clearance between bridge wall and bottom of boiler shell has been found to be one-fourth the height that the bottom of the boiler shell is above the furnace floor. For the reasons given above, the horizontal bridge wall is much to be preferred to the curved construction.

Chicago, Ill. R. O. BILLINGS

ANSWERING Bunyan Kennedy's question regarding flat vs. curved walls I would say that the main purpose of a bridge wall is to prevent fuel from falling off the grates into the combustion chamber. In addition it tends to increase furnace temperature by providing radiant surface, throws the gas current upward along the boiler shell, and is an obstacle to free flow of the gas, thus promoting its mixture with the air to improve combustion.

Curved bridge walls tend to prevent equal distribution of gas over the boiler surface and thus reduce its capacity. The flat bridge wall gives a better distribution of gas around the boiler shell exposed to the combustion chamber. When designing and proportioning the various gas passages and flues of a boiler, and its connections, the drop in gas temperature and friction as a draft-retarding factor must be considered. A common rule for bridge walls is to make the area between the bridge wall and the boiler shell equal to 1/7, the flue area 1/8, and the chimney 1/9, the area of the grates. If a flat bridge wall is used and set 14 in. from the lowest point of the boiler shell, the draft area on a 72-in. h.r.t. boiler will be approximately double the boiler-tube area and on a 54-in. boiler it will be about three times the tube area.

Woodbury, N. J. R. W. CATER

"Humming" in Boilers

ON PAGE 103 of February *Power* Frederick W. Johns of Manchester, England, inquires relative to humming of boilers. We had a very serious case of this at our Boone, Ia., plant—in fact, it became so serious that a

writ of injunction was threatened to shut down the station.

Our investigations indicated that the basic trouble was due to the large quantity of hydrogen and methane evolved from the fuel, highly volatile coal. This goes back to singing hydrogen flames of Physics-class days. To take care of this, we did three things.

1. We put in some overfire air in order to burn properly these rich gases immediately above the fuel bed.

2. We changed the shape of the resonating chamber (the first pass of the boiler), by building up the side walls to the top of the drums and laying "T" iron across the drum and side walls. This was then covered with refractory. This had the effect of changing the organ pipe so that it would not resonate.

3. We put plows on the feed gate of the stoker approximately 4 in. in depth and on 12-in. centers for cutting grooves in the fuel bed entering the furnace. This permitted more preliminary air to go up through the fuel bed further to increase the speed of combustion and localize it in the fuel bed.

This particular stunt, one of the firemen discovered. He found that if he ran a slice bar in on top of the fuel bed through the feed gate and hopper, thus stirring up the fuel bed, the drumming or humming would cease.

With these changes, we have operated this boiler plant for nearly four years without any complaint from people living in the vicinity of the power station.

Cedar Rapids, Ia. JOHN M. DRABELLE,
Mechanical & Electrical Engr.,
Iowa Electric Light & Pwr. Co.

More on "Humming"

A BAD case of boiler "humming" came to my attention in 1930 at the power plant of the University of Missouri. The guilty boilers were horizontal, water-tube, long-drum units, fired with natural-draft, chain-grate stokers. At a certain boiler loading, the boiler would begin to hum, going from an intensity barely audible to one that required shouting to be heard over it, in the short time of about ten seconds. When the load was increased or decreased away from the humming point, the noise faded away.

At maximum amplitude, the humming was so loud that on quiet summer nights, with boiler-room doors and windows open, it could be heard a mile or more away.

The firemen learned that by poking a 2 x 4 timber just above the chain grate through the green-coal bed (and under the stoker hopper) into the furnace, the humming would stop for a few minutes. Since the hole thus opened through the coal bed into the furnace admitted overfire air temporarily, it was reasoned that the humming might be caused by secondary combustion of carbon monoxide (and perhaps hydrogen) among the bolier tubes. This secondary combustion would be due to incomplete combustion in the boiler furnace, in turn due either to insufficient air supply or lack of turbulence.

Accordingly, it was decided to try overfire air jets. A fan that would deliver 5% of the total combustion air required at top rating and at a pressure of 16 in. of water was installed over the arch of the worst "hummer." A manifold connected to the fan supplied air to four jets across the 10 ft. furnace width. The jets were made of 1-in. std. pipe, the ends being left back in the arch tile about $\frac{1}{2}$ in. as a protection from radiant heat. The jets were set at an angle of 60 deg. with the horizontal, the air striking the fuel bed 3 ft. in from the coal gate.

Use of this overfire air, small in quantity but high in velocity, completely eliminated humming at any loading. It also eliminated all smoke resulting from burning of the high-volatile Missouri coal. To keep excess air down as much as possible, the overfire air is reduced to a value just above the humming point and also where the smoke from the stack is kept at a medium to light gray.

The "hum" is still potentially present. On one or two occasions, about three years after the use of overfire air was begun, the overfire-air fan kicked out. To the surprise of the fireman, who had nearly forgotten the humming nuisance, that deep bass note immediately appeared from the walls of the setting, filling the boiler room with its old familiar roar.

It would be interesting to know the circumstances of humming boilers fired with low-volatile coal, where incomplete or secondary combustion is less likely.

Columbia, Mo. R. H. SOGARD,
Supt., Dept. of Bldgs.,
University of Missouri

Steam-Flow Air-Flow Relation or CO_2?

WITH reference to the comments of E. B. Bossart in the January number on the article "Spotless Dixie Plant," which appeared in November *Power*, it might interest some readers to know that we operate a steam-flow air-flow meter and a CO_2 recorder side by side. Charts from each are here reproduced.

In general operation of the boiler, which is pulverized - coal fired under manual control, the operator pays little or no attention to the CO_2 chart, furnace conditions being regulated entirely by the indications of the boiler meter.

The CO_2 chart is used essentially as a matter of record and as a check when making changes from bituminous coal to lignite or to oil. The CO_2 recorder has been in almost constant service for more than 20 yr., most of which was on stoker-fired boilers. It is a very simple and practical instrument using city water for motive power. The only attention necessary is to run it occasionally on air only for a short period and change the caustic twice a month.

Regina, Sask. A. L. COLE

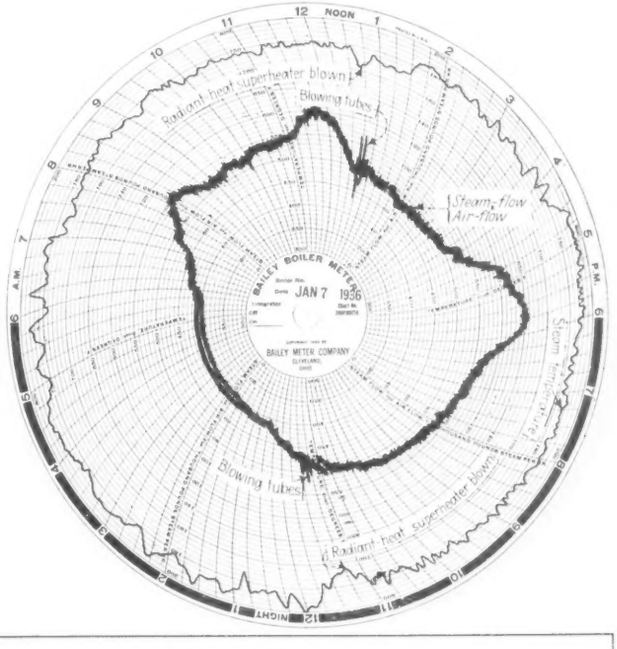
Engineer Vs. Operator

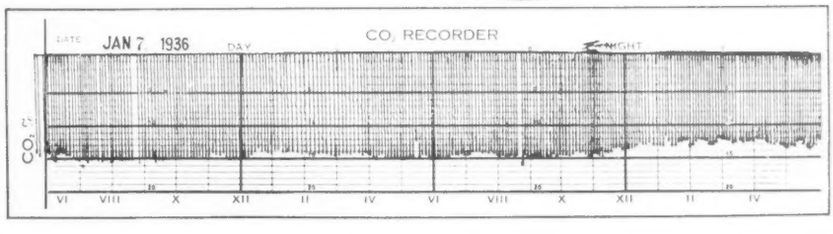
WHY all this noise about the difference between an engineer and an operator? It all sounds like a lot of comedian's wise cracks to us. It all ends up by being the same thing, no matter how a man learned what he knows.

We would like some of the wise ones to tell us where they would put our Boss. I will jot down some of the gear for which he is directly responsible.

Six B & W water-tube boilers, two 4,850-kw., a.c. generators, four 350-kw., d.c. generators, four surface condensers with their attendant air extractors, seven condensate pumps, four circulating pumps, two sanitary pumps, two Terry-driven pumps driving water to boilers, two feedwater heaters, two evaporators, ten steam-driven reciprocating pumps, two forced-draft blowers, fuel-oil burning apparatus handling 100 tons of fuel per day, 37 ventilating fans and systems, one 30-ton CO_2 refrigerating compressor, one 100-ton Freon refrigerating plant, two 6,300-hp. synchronous motors, twenty 50-hp. motor-driven hoisting engines, a 10,000-sq.ft. heating system and all the modern equipment, plumbing, kitchen gear that goes with a hotel.

The only sheepskin this chap has is the one that keeps him warm. His grammar is





rotten, he has no line of "boloney," but he is one of the two men I know who says I don't know when he doesn't. But leave it to him—he will know within 24 hr.

Strange to say, he has no trouble cutting in or out boilers, no valve bonnets raising or valve disks clattering, no water carryover, no boiler tubes falling down, no chemist to take care of feed or boiler water and no breakdowns, no outages due to inattention or negligence. To my knowledge he has an unexcelled performance for the ten years I have worked with him. The nearest this man got to college was when as a boy of eleven he delivered pies to a university restaurant.

My usual experience with technical graduates has been that they are so technical there is no room in their heads for horse sense. When these fellows with technical educations forget the high hat and slide rule, and work hand in hand with the old-timers, we will have both better engineers and operators, because there is nothing like experience coupled with a technical education. I wish I had the latter.

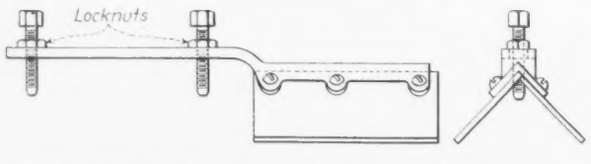
On cutting in boilers, I would like to ask J. M. Myers why men should be carried who are too lazy to cut out a boiler instead of dead-heading, whatever that means. Also, there is no reason to carry such dumb fellows as R. A. Hafford's young firemen who cannot grasp an intelligent order. Issue intelligent orders, then see that they are carried out. You can't run a plant over a telephone. Have a look around once in a while and go where the boys are supposed to go. When they see you are on the job, they will be too. Get a bunch of good lads, train them properly, and then, as Brother George Edwards says, you can go fishing.

I hope someone will answer my question, because the way I feel about it is that if I had the combination of a technical education and my Boss's brains, I wouldn't have to work for a measly $100 a week.

Colon, R. P. SILAS DEWEES

Tool for Aligning Two Shafts

IN RECENT numbers of *Power* there has been considerable discussion on how to line up machines on the two halves of their coupling. I wish to submit a method of lining up two shaft ends without a coupling. The tool for doing this is shown in the diagram. It is



made from a section of keyseat rule with an extension bar forged from a piece of steel.

Two holes are drilled and tapped in the bar for short ⅜-in. adjusting screws. The bar should be of sufficient length so that the screws can be placed at least 6 in. apart. Before the tool is used, it is placed on a section of shafting known to be straight and the screws carefully adjusted to a convenient gaging distance from the shaft and locked into position.

To align two shafts, one must be first properly leveled into position. The other shaft is aligned by placing the tool on the one that has been positioned and gaging between the screws and the shaft to be aligned. When the gage distance between the screws and the shaft is the same at four points 90 deg. apart, alignment is correct. If the positioned shaft can be turned easily, the tool may be taped to it and then rotated to bring the tool into the gaging positions.

Cohoes, N. Y. ARTHUR W. BLUM

When to Renew Hoist and Elevator Ropes

I HAVE been interested in the discussion on how frequently ropes on elevators and hoists should be inspected. It is my opinion that on most elevators and hoists you can save yourself from doubt as to rope condition by a rigid monthly inspection. Faulty installation of, or worn grooves on, sheaves will cause uneven wear on ropes. A monthly inspection will reveal this before the ropes have been damaged.

There are many conditions affecting rope life, such as diameter of sheaves, condition and shape of grooves, number of bends and their direction, car speed, length of travel, etc., all of which make it hard to determine rope life. For ordinary service, rope life should be from three to five years. 6 x 19 standard construction ropes should be replaced if the number of broken wires in any one strand reaches six, or when the wires on the crown of the strands are worn to less than 65% of their original diameter.

Broken wires on the surface of a rope are not always a true indication of its condition, for corrosion may attack the strands. When this is apparent, ropes should be discarded regardless of other conditions.

Kalamazoo, Mich. HARRY NELSON

Cutting In a Boiler

IN THE discussion on cutting in a boiler in February *Power*, Harry M. Spring states: "If the disk of a non-return valve opens, it is safe to assume it will close." I cannot agree with this statement.

We have never had any trouble from non-return valves not opening, but have had trouble with them not closing.

Our valves are of the angle type with the disk in the shape of a plunger, with two snap rings near the upper end and working within a liner which carries the seat.

Our first trouble due to these valves not working was the blowing of mercury out of the flowmeters while blowing the tubes during low-steaming rates. As the soot-blower connection is out of the drum and the rate of steaming was not sufficient to supply the demand of the soot blower, there would be a back flow of steam from the other boilers sufficient to blow the mercury out of the flow meters but still the non-return valves would not close. This trouble was eliminated by removing both rings from the disk.

Cleveland, Ohio THOMAS C. BROCK

More on Cutting In

IN THE last few issues of *Power* there has been some interesting as well as amusing discussion of steaming and cutting boilers in.

The 6-yr.-old plant with which I am connected includes two 4,850-kw. a.c. generators, four 350-kw., d.c. generators, six B & W interdeck superheater-type boilers, 300 lb. pressure, 200 deg. superheat. We have the original boiler tubes, have had no accidents and have been cutting boilers in and out sometimes twice in 24 hr.

Assume a boiler has been off the line for cleaning, at the same time taking it for granted that all boilers have safety valves. Fill the dead boiler with water at 200 deg., with the drum stop open and the superheater air valves open. Start a slow fire and raise pressure to 15 lb., then close the drum air valve and adjust the superheater air valves to permit circulation through the superheater. Raise the pressure slowly until the safety valve lifts and blows fairly strong. Then check the fire for 15 min. and lift the safety valve once again. Lower water level to 1-in. glass by surface blow. When pressure is 15 lb. less than line pressure, and fires checked and drain on line side of main stop open, ease the main stop and let pressures equalize. With the drains still open, slowly open the main stop, then close all drains. The boiler is now on the line, so fires can be started.

Hoboken, N. J. BENJ. FRANKLIN

About That "Weak Link"

I DO not quite understand Mr. Gibbons' letter on the above subject (Feb., page 104). It appeared to me that George Edwards (Dec., 1935) was quite right in his assertion that it was the management who, in most cases, needed educating about new equipment, etc. Closer cooperation between manager and engineer is required to give full, 100% efficiency. Too often, the office acts upon the suggestion of some high-pressure salesman or too-optimistic consulting engineer and installs something at a high price which the operating engineer could have duplicated for much less.

If the executives decide they cannot afford new gear advised by their engineer they are usually wrong, because it stands to reason that the engineer is quite anxious to give efficient service or he will be out of his job. I can give a little instance that came to my notice less than a month ago.

A plant owner was told by his engineer that he was having trouble getting water into the boiler. Believe it or not, he did not wait to ask the engineer for his remedy, but proceeded to order a large injector. Of course, this did not solve the problem, and this extremely foolish owner was greatly surprised when he found that it was gradual closing of the feed line by scale that was impeding the flow of the water. This seems quite incredible, but it is true.

I am strongly at variance with Mr. Gibbons when he states that the engineers are in closer touch with the management in a large concern. My experience, quite wide, has been just the opposite.

Passaic, N. J. MARK BELL

READERS' PROBLEMS

QUESTIONS for Our Readers

Broken Boiler Brace

Question 1

IN OUR *boiler plant, we have several horizontal-tubular boilers. They have 18 diagonal braces from the head to the shell in each head. Recently we found one of these braces broken in the middle. No sign of distress has developed, and I would like to know if this brace can be welded. Is it dangerous to run with one brace out of 18 broken?*—H.H.R.

Changing Diesel Piston Rings

Question 2

WE HAVE *a 300-hp. diesel that has been giving us only 1,000 rated hp.-hr. per gal. of lubricating oil. Our belief is that rearrangement of the piston rings will reduce oil consumption without detriment to engine operation. These pistons now have four rings at the crown. Our belief is that a wiper ring on the skirt and a wiper ring replacing the lower ring at the crown will solve the problem. Is this logical, and if so, will it require any change in lubrication methods?*—A.V.M.

Suitable answers from readers will be paid for if space is available for publication.

SHOULD PATENT OR CAPITAL COME FIRST?

ANSWERS to February Question 1

The Question

ASSUMING *that an invention has reached the drawing board and been conditionally approved by competent engineers, what is the next step? Does the inventor wait for capital, perhaps indefinitely, or is it good business to submit it to anyone in its unprotected, undeveloped state? The logical procedure, of course, is to patent and develop one's creation. Lacking means to do this, is there no second choice?*—F.A.J.

Don't Confide Ideas

DON'T take too many people into your confidence on new ideas. There are many people ready to pirate ideas, or in large organizations to claim credit for the idea of a subordinate. I would advise F.A.J. to get only absolutely necessary outside help until he has applied for the patent. After application has been made, it is reasonably sure and he can go about getting outside help or a purchaser. Complete information on the procedure in filing for a patent can be obtained from the Patent Office in Washington, and actual fees are very low.

Waynesboro, Va. J. M. MYERS

How to Protect an Idea

GREAT numbers of inventions reach the drawing board, are conditionally approved by competent engineers, then never get any farther. In other cases, the inventor obtains sufficient capital, or uses sufficient capital of his own, to obtain patent rights, and later goes about developing the idea and reducing it to practice. But that is really putting the cart before the horse. Development of the idea should really precede application for patent, because it is quite possible that points and factors will arise during its development and reduction to practice, which will permit a deeper insight leading to the obtaining of broader claims and a far more valuable patent. Development of the idea should therefore be the first concern of applied capital.

On the other hand, some insurmountable difficulty may possibly arise during the development of an idea which could not be foreseen upon the drawing board. In such a case, putting development first may easily save the cost of searching the patent office records for prior art, and also that of applying for, and even possibly obtaining, a more or less worthless patent.

In actuality, far fewer patents are stolen than are commonly reported stolen. Jones has an idea, shows it to his friend Smith, and through neglect, lack of capital or for some other reason fails to go ahead with the idea. Some years later, a Mr. Brown over in a neighboring state applies for patent rights on a somewhat similar device. Jones encounters the device some years later, and never gets over the idea that Smith somehow allowed the information to leak out.

After all is said and done, however, it must be admitted that there is but the slimmest chance for even a splendid idea to prove successful for the man without capital. Everything is against success unless a man has both the means and the ability to push development to a successful conclusion, to obtain the broadest possible patent protection under the law, to manufacture the item or to have it manufactured if a buyer cannot be found, and to execute a sales and advertising campaign of sufficient strength to make the class of consumers who should be interested in his product unable to remain indifferent to it. Unhappily, many of us are unable to appreciate that such a thing can be true unless and until we have first singed our wings.

Peoria, Ill. JOHN E. HYLER

Trust Reputable Prospects

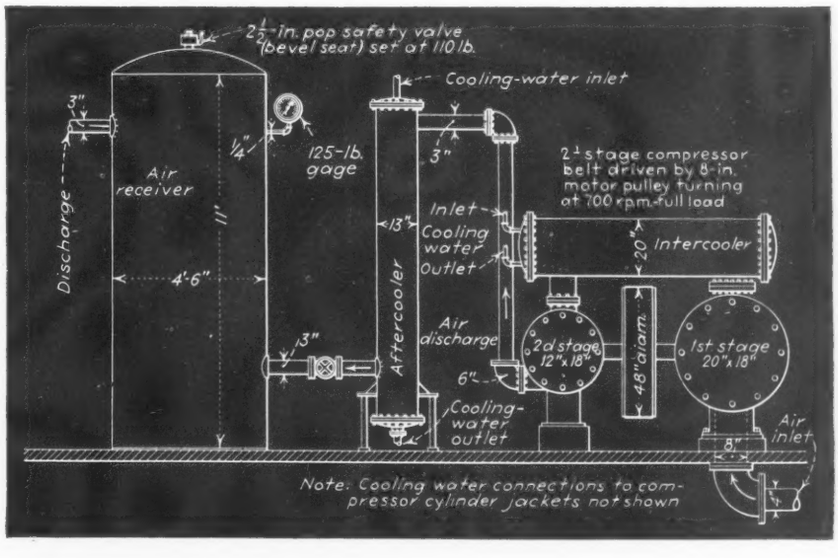
F.A.J. will do better to study what company is most interested with his idea. A well-written letter should be sent to them, directly addressed to an individual if possible, and the idea outlined in it. A request for a personal interview should, of course, accompany it.

It is my experience that this is the best approach. The higher one gets in most organizations the more sympathy and courtesy

WHAT'S WRONG WITH THIS PICTURE?—III

COMMON ERRORS IN COMPRESSED-AIR SYSTEMS

THERE are at least 16 mistakes shown in this drawing. Make a list of those you can recognize, then check against the list on page 227



one meets. Really good business executives cannot afford to let slip any idea for improving their product or directly affecting it; it is only the minor employees who are liable to be cavalier in their treatment of the outsider making a request.

In a recent experience, I received the most considerate treatment at the hands of the heads of four large companies, and I believe that any reputable business firm would not consider the barefaced appropriation of an idea without compensation. It would be far simpler for them to come to a financial arrangement with the inventor than run even the faint chance of subsequent litigation and unfavorable publicity.

Passaic, N. J. MARK BELL

Register the Idea First

I WOULD most assuredly advise the inventor against application for patent with his idea in its present state. Patent applications are available to the general public almost immediately after they arrive at the patent office. The application would be valid, the inventor protected, and a patent issued providing the idea was considered practical or feasible, or that no previous patents were issued or applications executed, or that the idea had never been used or registered previously. However, as the inventor states, the idea is undeveloped, and anyone could start development from the information given in the application. It is possible in this way that additional features would be developed which would be patentable. At the same time, even if the idea had been used, registered or patented before, it is possible that it may possess patentable features.

I suggest that the inventor register his idea immediately. A patent attorney can do this, or he can do it himself. Write a description of the idea, making the claims as broad as possible. Have made a set of drawings or sketches. Keep exact copies for reference. Take one set to a notary and have it notarized to the effect that he is the inventor and that all ideas contained therein are original. Have the notary place the papers in an envelope and seal it, having the date placed on the outside. He should address the parcel to himself, have it registered at the post office, and drop it in the mail. It can also be sent special delivery for additional record. When the parcel is received it should be deposited in a safety deposit box. For additional record the one in charge of the deposit boxes may signify on the parcel the date it was deposited. In this way the idea is registered with a notary, twice at the post office in addition to the post mark, and at the safety deposit vault. This definitely establishes the date of origin of the idea and no court can disregard the evidence. This parcel should never be removed from the deposit box without sufficient witnesses to establish the cause and it should never be opened except in the presence of a court or of competent witnesses.

It is usually bad policy to divulge the contents of a patentable idea to anyone as this inventor has to his engineering friends. However, since he has already divulged the idea to friends, their testimony is valuable in court proceedings to establish the date of origin. Theoretically, an idea is protected from the time an inventor divulges it to some other individual; however, the sad part is that the burden of proof rests on the inventor.

The next wise step is to analyze the merits of the idea to determine its marketability. If there is no market for the product, the expenditure for development and patent fees will be totally wasted. Inasmuch as the inventor lacks capital he would be in no position to market his product, even if he could develop it. The services of a competent patent attorney should be secured to conduct a complete investigation to determine whether or not there were any previous patents or patent applications and to determine the patentability of the idea. This can be done at an expenditure of about $25.

After all necessary investigation has been carried on and protection secured, the most logical procedure is to contact some well-known and competent manufacturer of equipment embodying the idea, giving him the merits of it, yet not disclosing it. Should he be interested it is well to have an attorney formulate disclosure papers stating that he will consider it for a definite period within which he will either accept the idea or reject it. The papers should contain all agreements between the inventor and the manufacturer as to royalties and other monetary considerations. Since protection has already been secured, this procedure is additional insurance and may prevent useless and expensive court proceedings.

By registering an idea, the inventor will delay the date of issuance of a patent until such time as the product will be ready for the market and will realize the profits for his product for a longer period of time. The life of a U. S. Patent starts from the date of issuance. Generally the maximum time necessary to secure a patent is two years from the date of application. The period of duration of a U. S. Patent is seventeen years from the date of issuance, and it cannot be renewed.

Toledo, Ohio K. J. BERNHARD

WILL LIME PURIFY CALCIUM BRINE?

ANSWERS to February Question 2

The Question

WE HAVE *an ammonia-brine refrigerating system and the tank holds 2,500 gal. of brine. We had an ammonia leak in the brine tank and lost 200 lb. of ammonia. We ran off all the brine into the sewer and made fresh brine. We were told that we had wasted a lot of time and money as a few shovels of lime put into the tank would have neutralized the ammonia and purified the brine. Even though this were so, would it not wear out the pumps?*—J.S.B.

If No Corrosion Treatment Use Chromic Acid

THE contamination of brine with ammonia can be corrected by acids as the ammonia gas reacts in the brine system to form ammonium hydroxide which is a strong alkali. The addition of any other alkali as a neutralizing agent is obviously ridiculous. The addition of lime to an ammonia contaminated brine system would have a tendency to increase the alkalinity of the brine resulting in the deposition of calcium oxychloride, calcium carbonate and calcium hydrate causing very unsatisfactory conditions.

When a brine has been contaminated with ammonia, the most satisfactory method of neutralizing the alkalinity is through the introduction of hydrochloric or muriatic acid which provides an ion common to the system. In brine systems which have not been treated for corrosion control, phosphoric acid or chromic acid may be used to reduce the alkalinity. Phospho glucosate and acid chrom glucosate may also be used for this purpose and will have the effect of removing deposits of calcium oxychloride which may occur before correction of the brine. Carbon dioxide is sometimes used to correct the alkalinity of ammonia contaminated brines. However, I would not recommend this as it is likely to cause the deposition of calcium carbonate and as carbon dioxide, in solution, is in itself a corrosive gas it may represent a dangerous substance to add to the brine system.

In the case of small brine systems, it is frequently more economical and satisfactory to discard the brine than to treat it following a case of excessive ammonia contamination. In this instance, J.S.B. probably followed the most advisable course, in making up new brine. Any time, however, that it is desired to correct such a condition chemically, the services of a competent chemist should be obtained and the additions of acid material should be made cautiously, with frequent tests of the brine.

Chicago, Ill. DAVID W. HAERING

Heat Brine To Drive Off Ammonia

WHEN calcium-chloride brine becomes contaminated with ammonia, the following conditions may exist:

1. If the brine contains neither carbon dioxide nor chemicals other than calcum chloride, the ammonia will remain in a free state and no amount of lime will neutralize or act upon the ammonia in any way.

2. If the brine contains carbon dioxide in solution, as is usually the case, the ammonia will react with the carbon dioxide to form ammonium bicarbonate, and thus become "fixed." Any excess of ammonia will remain in a free state. In this case, lime added to the brine will react with the ammonium bicarbonate, liberating the ammonia and precipitating calcium carbonate as a sludge. Therefore, nothing has been gained as to the removal of ammonia and we have a sludge, where there was none before. Incidentally, if the fixed ammonium bicarbonate is to be broken down (as is necessary for complete ultimate removal of the ammonia) it would be better to use caustic soda instead of lime. In that case sodium carbonate is formed instead

of calcium carbonate and no precipitation of sludge takes place.

As to the removal of ammonia from the brine, the most satisfactory and effective method is to heat the brine, which will drive out the free ammonia. Fixed ammonia (in the form of ammonium bicarbonate) is first liberated with caustic soda.

In this connection it should be mentioned that the leakage of a small amount of ammonia into the brine will not harm the brine in any way and need not be removed, unless there are special conditions such as:

1. If the contamination is sufficient to cause objectionable odors or to corrode copper coils and brass valves.

2. If the brine is used for direct spray cooling of food products, contamination with ammonia might affect the taste or flavor.

3. If the brine contains magnesium chloride, in addition to calcium chloride, as is often the case, ammonia will react with the magnesium chloride, causing precipitation of a heavy sludge and forming ammonium chloride, which is very corrosive.

Old Bridge, N. J. A. J. LUBELEY

Use Carbon Dioxide

WHEN a quantity of calcium brine becomes contaminated with ammonia it will require more work than a few shovels of lime to correct the malady. In fact, lime is not the proper prescription and will not neutralize a solution that is already strongly alkaline, which is the case of a brine well polluted with ammonia.

Assuming the brine in question to be a straight calcium-chloride solution, there would be no precipitation; but on the other hand it would become highly corrosive and, naturally, damaging to the brine system.

To remove the ammonia entrained in the brine, J.S.B. could have arranged steam coils in the brine tank and raised the temperature of the brine to its boiling point. By this procedure the excess alkalinity of the brine would be removed. Another method just as effective, but probably not as complicated as the heating process, is to treat the brine with CO_2 gas. The CO_2 gas, to be most effective, is usually introduced into the brine at a point where there is the most agitation. In either case a sample of the brine should be tested by a competent chemist to find its pH value. A pH of 8 is a recommended and accepted condition. It might be advisable for the plant in question to have a test made of its new brine solution, a residuum of the former batch might have defiled it.

Cumberland, Md. CLARENCE F. ALSIP
Celanese Corp.

Use Hydro Chloric Acid

J.S.B.'s procedure of replacing the brine was wiser than retaining it and scheming out a manner to preserve it. A brine contaminated with ammonia becomes very alkaline and highly corrosive on steel and will destroy galvanizing totally in a matter of hours.

The brine having become highly alkaline owing to ammonia hydroxide forming and possibly ammonia chloride (sal-ammoniac) the addition of lime treatment suggested would only increase its alkalinity and compound the difficulties. The tried procedure that has been found most effective in many more serious leaks than this one has been to neutralize the brine with commercial hydrochloric acid (muriatic acid) and bring the pH value down to between 7 and 7.4

Whenever possible it is preferable to first aerate the brine through a spray pond or over a cooling tower; if such is available this will dissipate considerable of the ammonia into the atmosphere. Even pumping the brine over open condensers will help materially to dissipate much of the ammonia.

Incidentally, a brine system properly treated with sodium dichromate before hand will protect all metal in contact with it against the corrosive effects of a brine contaminated with ammonia.

New York, N. Y. R.T.B.

WHAT'S WRONG WITH THIS PICTURE?—III

COMMON ERRORS IN COMPRESSED-AIR SYSTEMS—SEE PAGE 225

ERRORS shown are of a type which tend to create a hazardous condition either for breakdown of parts, a hindrance to proper operation, or possible rupture of parts under pressure with corresponding serious results.

1. *Safety Valve too Small.* The relieving capacity of the valve, as figured from the A.S.M.E. formula; $Q = 28 \times P \times D \times 1 = 28 \times 110 \times 2.5 \times 0.06 = 462$ cu.ft. of free air per min., assuming a 0.06-in. lift for the 2½-in. safety valve.

Compressor speed is figured from the ratio of the motor and compressor pulley diameters, or: $\frac{700 \times 8}{48} = 106$ r.p.m. The capacity of the compressor at this speed is:

$$\frac{20^2 \times 0.7854 \times 2 \times 18 \times 106}{1{,}728}$$

$=675$ cu.ft. of free air per min.

This is considerably in excess of the safety valve relieving capacity. If the unloader on the compressor should stick and compressed-air demand were low, an over-pressure would result on the system.

2. *Safety Valve Does Not Protect Compressor or Aftercooler.* The stop valve between the air receiver and the aftercoooler might be accidentally closed. In this case there would be no relief of pressure for the aftercooler or compressor. Rupture of parts from excessive pressure might result.

3. *No Safety Valve on Intercooler.* In case of obstructed air flow to the 2nd stage cylinder of the compressor, an over-pressure might cause rupture or other damage to the intercooler or first-stage system. A safety valve of such capacity that will relieve all air that can be discharged by the first-stage cylinder should be provided. It should be set at a pressure not in excess of the pressure allowed by construction of the first-stage system as specified by the manufacturer.

4. *No Pressure Gage on Intercooler.* A pressure gage should be provided on the intercooler to check on conditions set forth above.

5. *No Drain on Intercooler.* A drain should be provided on the intercooler to draw off condensate, oil, etc.

6. *No Drain on Aftercooler.* Reduction in temperature of compressed air results in condensation of a considerable amount of moisture. Oil and other foreign matter also settles on the bottom. This causes loss in effective volume and cooling surface, as well as creating a hazardous condition in event of cooling water failure. High temperature may cause spontaneous combustion of carbonaceous oil deposits with resultant explosion.

7. *No Drain on Air Receiver.* A drain line should be provided on the air receiver for the above reasons.

8. *No Syphon on Pressure-Gage Piping.* A water leg or syphon should be provided in the pressure-gage line to protect internal parts from overheating and becoming defective in event of high air temperatures resulting from loss of cooling water.

9. *No Test Connection on Pressure-Gage Line.* A ¼-in. branch connection should be teed off of the pressure-gage piping and fitted with a ¼-in. threaded cock. This serves for connecting a test gage to determine accuracy of the pressure gage.

10. *No Shut-off Cock for Pressure Gage.* A shut-off cock with tee or lever handle should be provided in the pressure-gage line. This is so the gage line may be temporarily shut off for changing gages, without shutting down the system.

11. *No Pressure Gage between Compressor and Stop Valve.* A pressure gage should be installed between the compressor and the stop valve so that the pressure will be indicated if this valve is closed.

12. *Reduction in Inlet Diameter.* Any reduction in inlet pipe size will cause loss in compressor efficiency with corresponding waste in power per unit of compressed air.

13 *Reduction in Discharge Piping Diameter.* Any such reduction in discharge piping such as is shown in the sketch will cause trouble. There will be a high back pressure on the compressor, with corresponding waste of power, excessive pressure and temperature.

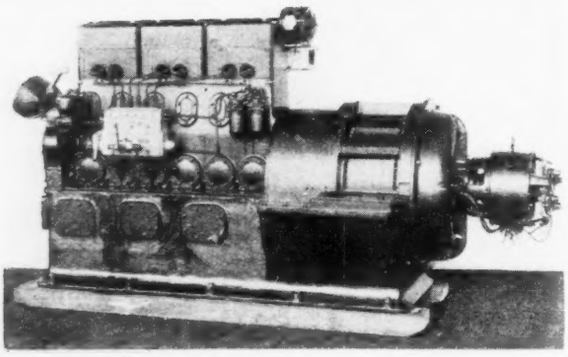
14. *Bottom of Air Tank on Floor.* Moisture collecting externally on the concave head often causes serious corrosion. By installing the air receiver on masonry piers or metal framework, ventilation aids in keeping this head dry. A clearance of at least 12-in. is recommended so that the lower head will be accessible for inspection.

15. *Pressure-Gage Calibration Too Low.* The pressure gage should be calibrated to approximately 1½ x the maximum allowable working pressure (in this case the m.a.w. pressure was assumed to be the same as the safety-valve setting). A pressure gage calibrated to 165-175 lb. would be required. A pressure gage calibrated to a lower value than this could not indicate the true pressure rise above normal if the safety valve should stick.

16. *Filter on Suction.* Though not required by code, it is good practice to install a filter in the suction line. This keeps dirt out of the compressor and system, preventing excessive wear of moving parts.

Brookline, Mass. HARRY M. SPRING

WHAT'S NEW IN PLANT EQUIPMENT



DIESEL-ELECTRIC SETS

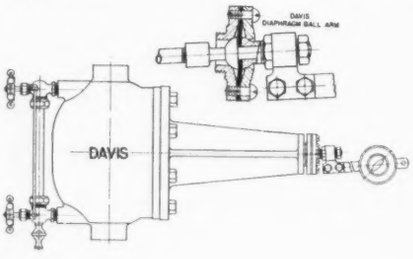
SUPERIOR. Model GA, 2, 4 or 6-cyl., $4\frac{1}{2}$x$5\frac{3}{4}$-in., 4-cycle, cold-starting solid-injection diesel sets deliver 10 to 50 kw. at 1,200 r.p.m. Cylinder and crankcase enbloc, with removable cover plates and handhole covers. Pistons can be removed from above. Wet-type interchangeable alloy C. I. liners. Nickel alloy iron heads cast in pairs, and overhead valves. Interchangeable cylinder-head covers, readily removable for valve adjustment. Self-contained fuel pump with individual barrels and plungers for each cylinder. Pintle-type nozzle. Vertical centrifugal governor. Pressure lubrication. Electric starting, with provision for compression release and increase. Operates on 28 to 36-deg. Baume fuel. Lubricating and fuel-oil filters, lubricating-oil pump, water pump, oil cooler, fuel-transfer pump, battery-charging generator, air filter, water-cooled exhaust manifold and panel with lube-oil pressure, ammeter, and cooling-water temperature dials are standard equipment. Exciter for a.c. units. Single-lever control. **Bulletin 535.**

Otto Engine Works, Holmesburg, Philadelphia, Pa.

LOW-PRESSURE TEST GAGE

PRESSURES from 0 to $1\frac{1}{2}$ lb. are indicated on dial calibrated from 0 to 35 in. of water and from 0 to 20 oz. in this "Figure 50" test gage. Has bronze diaphragm with mechanism independent of case. $2\frac{1}{2}$ in. diam. black steel case, nickel ring and $\frac{1}{4}$ in. pipe thread bottom connection or in cast aluminum case $2\frac{1}{4}$ x 5 x 6 in. with 3 ft. of flexible hose.

Fisher Governor Co., Marshalltown, Iowa



PACKLESS FLOAT BOX

FLEXIBLE diaphragm-ball joint construction eliminates packing in float boxes for valves, switches, signal or indicator operating purposes. Diaphragm is made of Duprene, Dupont's synthetic rubber. Pressure thrust is carried by ball-joint, outside of which is lubricated with graphite grease.

Davis Regulator Co., 2540 S. Washtenaw Ave., Chicago, Ill.

CORROSIVE SOLUTION FEEDER

MODEL "E" chemical proportioner feeds such corrosive solutions as hypochlorite, sulphuric acid and ferric chloride into liquid lines for water treatment. Inlet line (A) extends inside tank into top gage thence to sight feed to count drops being fed per minute. Tank I filled with colored oil, lighter than reagent in Tank II. Flow pressure causes oil to go from I to II, forcing reagent out of rubber-lined Tank II into liquid line. Booklet.

D. W. Haering & Co., Inc., 3408 Monroe St., Chicago, Ill.

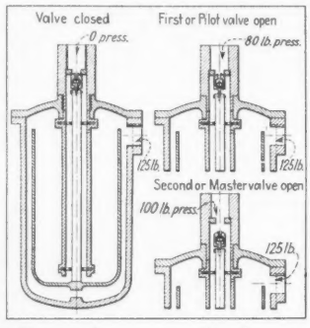
REMOTE VALVE CONTROL

MANUAL remote control will change pressure on diaphragm motor of controlled valve as little as $\frac{1}{4}$ in. of water. Used in conjunction with "Stabilflo" valve. Controlled flow can be changed by less than 1%. Will operate through several hundred feet without pumping or vibrating. Finished in lacquered cast bronze trimmed with buff nickel.

Foxboro Co., Foxboro, Mass.

IMPROVED HIGH-CAPACITY STEAM TRAP

REDESIGN of discharge valve has increased capacity of Type AE steam trap 3 to 4 times for a given weight. For example No. 15 trap weighs 15 lb. and has continuous discharge capacity of 1,400 lb. per hr. at 125 lb. pressure. Valve design involves no hinges or levers. When sufficient water accumulates in bucket, it loses buoyancy, pulling small valve away from its seat and allowing pressure to pass through holes in large valve plug to create back-pressure above. This causes the bucket to pull large valve from its seat. Water passes out through central tube, but leaves enough water in bucket bottom to form a water seal and avoid steam blowing at end of discharge. Air entering trap

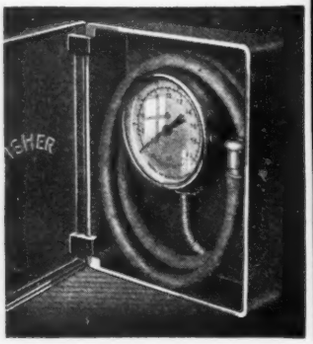


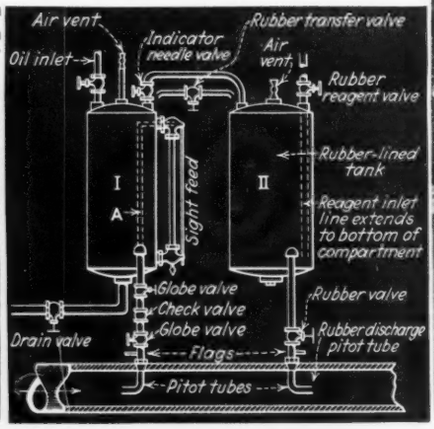
when valves are closed goes through vent into central tube, allowing water in tube to seek its own level, but passing out at beginning of discharge. Operation instantaneous, and bucket and valves rotate at each discharge, thus making unit regrinding. Working pressures to 200 lb., except for smallest trap, which is 150. Capacities 300 to 18,000 lb. per hr. continuous discharge. Pipe sizes $\frac{1}{2}$ to $2\frac{1}{2}$ in.

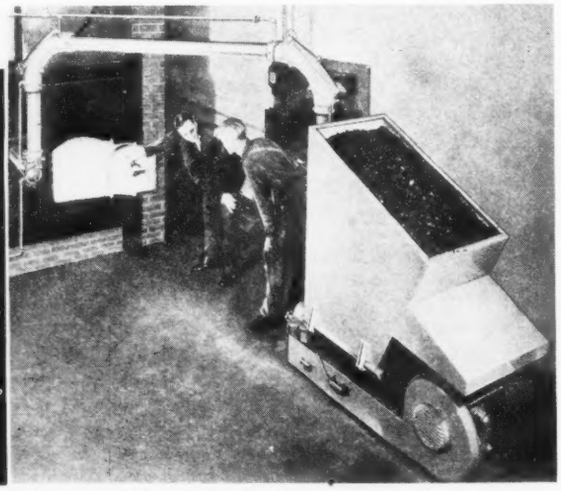
Stickle Steam Specialties Co., Indianapolis, Ind.

PNEUMATIC SPREADER STOKER

FEED worm measures up to $1\frac{1}{2}$-in. coal and conveys it from hopper or bin into transfer box, where it is picked up by air stream and carried to spreader nozzles in firebox. Finer particles burned in suspension. Larger pieces spread in shallow layer and burned so





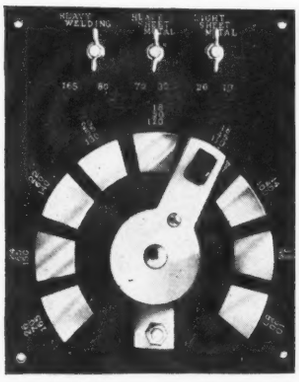


that temperature at grate line is below fusion point of ash and clinkers, which, therefore, are not formed. Available in five sizes, capacities 75 to 500 b.hp. Stoker located to suit conditions, usually 8 to 15 ft. from boiler front, or in separate room.

Iron Fireman Mfg. Co., 1305 S.W. 12th Ave., Portland, Ore.

DIAL SWITCH FOR WELDER

DIAL switch control for electric welder has amperage marked on switchboard, indicating each step in welding. Setting dial at top of figure gives operator absolute



control of amperage. Dial switch cannot "short" electrical circuit between contacts.

Miller Electric Mfg. Co., Inc., Appleton, Wis.

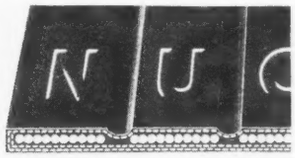
HIGH-SPEED, 4-CYCLE 7x8-IN. DIESEL

MODEL VL solid-injection unit is designed for 100 to 200 hp.@ 900 r.p.m. for stationary service and to 240 hp. @ 1,200 r.p.m. for light-duty service. 4, 6 or 8 7x8-in. cylinders. C. I. removable liners and aluminum-alloy pistons. All working parts accessible and renewable, but totally enclosed. Frame and cylinder head integral C.I. casting. Cam and lay shafts gear driven. Bosch fuel pumps and valves, the latter multi-orifice spraying into a pear-shaped combustion chamber. Pressure lubrication. Cast exhaust and intake headers, with water-jacketed exhaust header. Standard accessories include governor, centrifugal water pump, fuel-service and lubricating-oil pumps, fuel filter, and duplex lubricating-oil filter. For applications where light weight and compactness or high speed is desirable, for example generator or centrifugal pump drives or portable and semi-portable uses. Bulletin 79.

De La Vergne Engine Co., Paschall P. O., Philadelphia, Pa.

MULTIPLE FLAT BELT DRIVE

"NUCORD" multiple flat belts, grooved for pliability, said to be equivalent to medium double-

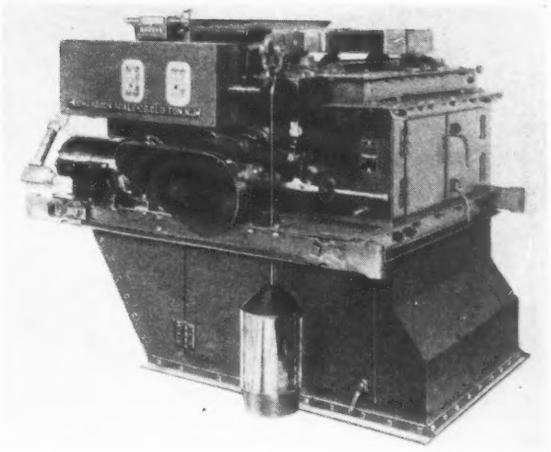


thickness leather belts or 5-ply rubber belts. Cords are gum dipped, then coated with special compound. Ten cords per inch of belt width. Endless belts up to 300 ft.; rolled belts up to 500 ft., and flat belts from $\frac{3}{4}$ in. to 12 in. wide.

Nucord Co., 605 West Washington Blvd., Chicago, Ill.

UNDERGROUND PIPE INSULATION

"ADSCO" Cell-Concrete insulation for underground steam and hot-water lines will retain physical strength and shape as well as



completely regain insulating value after repeated submergence in water. Made from portland cement mixed with foam, producing light-weight cellular concrete of 0.3 sp.g. Can be mixed on job and poured around one or more pipes in conduit of various constructions at low cost, resulting in rigid, permanent insulation.

American District Steam Co., North Tonawanda, N. Y.

SURFACE AND NEEDLE PYROMETERS

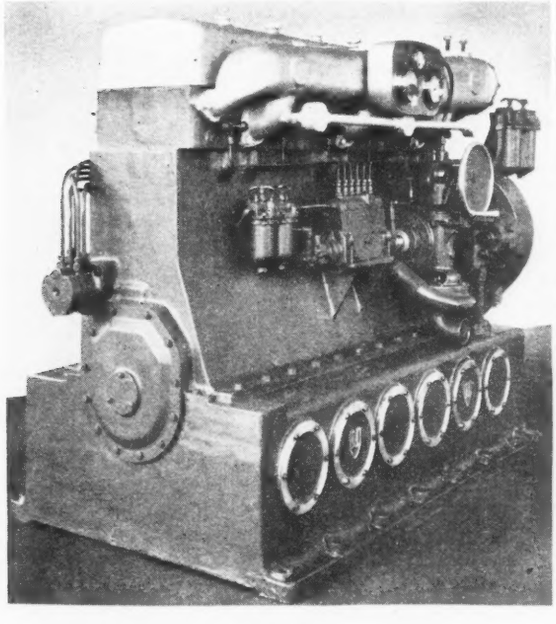
FOUR types of surface and needle pyrometer elements for use with one indicator. Type A-1 to determine temperature of molds of plastic or semi-plastic material or where small thermocouple contact (about $\frac{1}{4}$ in. diam.) is required, has universal joint. A-2 offset handle type for flat surfaces. B-1 for determining surface temperatures of stationary or moving rolls also has universal joint. B-2 has thermocouple in hollow needle. Bulletin No. 60-A.

Pyrometer Instrument Co., 103-5 Lafayette St., New York, N. Y.

AUTOMATIC COAL SCALES FOR SMALL CAPACITY BOILERS

SMALL-SIZE automatic coal scales of 50-lb. and 100-lb. unit or hopper-capacity sizes for use with small boilers, weighing coal to stokers or pulverizers. Coal received in scale top hopper, at bottom of which is short, slow-moving, wide conveyor belt which delivers coal to weighing hopper. Belt is driven by $\frac{1}{4}$-hp. gearhead motor with sprocket and chain. Motor controlled by mercury switches actuated by scale beam, automatically stopping on completion of weighing and restarting upon discharge of weighed coal. Brake prevents motor from coasting on open circuit. Discharge of weighed coal effected by electric solenoid upon completion of weighing. Machine interlocked so no coal can be passed unweighed. Weighings recorded and totalized on 6-figure mechanical rustproof and dustproof counter. 2 models—stationary with brackets, and portable with wheels for moving aside to clean boiler tubes. Two types—open for weighing to stokers, and inclosed for weighing to pulverizers. Weighs coal up to 2 in. in size. 50-lb. unit has hourly rating of 2 to 3 tons; 100-lb. unit hourly rating of 4 to 6 tons. Bulletin 2236.

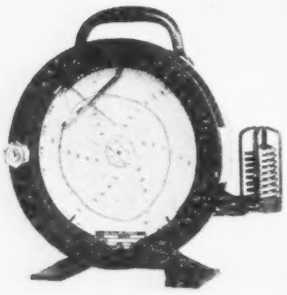
Richardson Scale Co., Clifton, N. J.



SPEED RECORDERS

FOR continuously indicating and recording speed at any desired location, regardless of distance from rotating member, "Micromax Speed Recorder" has heavy-duty tachometer magneto attached to rotating shaft, which generates electromotive force proportional to speed. Lead wires connected to Micromax recorder of type preferred. Recorder records on moving chart, or, if desired, actuates signals.

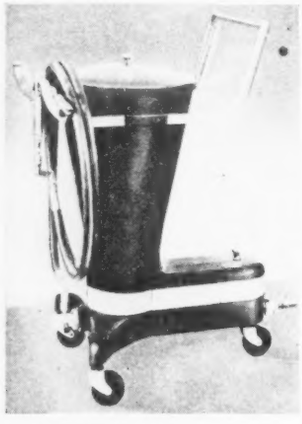
Leeds & Northrup Co., Philadelphia, Pa.



PORTABLE THERMOMETER

SENSITIVE element (bulb), mercury-filled, is mounted on outside of case for quicker response in this portable thermometer. Metal handle and legs on black-enameled, die-cast aluminum case. Gasketed, moisture-proof door with tamper-proof lock. Records on 8-in., 24-hr. chart.

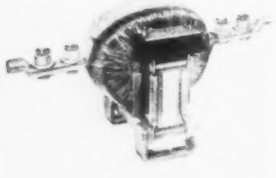
Brown Instrument Co., Wayne Junction, Philadelphia, Pa.



LUBRICATING POWER GUN

"ROCK CRUSHER" portable powerguns for industrial lubrication have twin guns (electric and air-operated) with capacities of 40 lb. Equipped with 10-ft. hose assemblies. Air-operated (RA-40) delivers 11 to 18 oz. of lubricant per min. at 150 to 200 lb. air pressure. Electric (RL-40), with universal motor, develops approximately 5,000 lb. pressure, delivering 9 oz. of lubricant per minute.

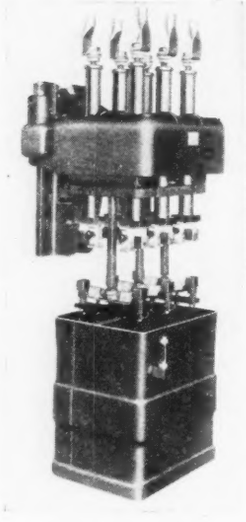
Alemite Division of Stewart-Warner Corp., 1878 Diversey Pkwy., Chicago, Ill.



SECONDARY TERMINAL BLOCK

MOLDED secondary terminal block for current transformers has conducting parts embedded in molded phenolic insulation. Short-circuiting strap manually operated. Cover cannot be removed without disturbing electrical connections, and cannot be seated in position while secondary is short-circuited. Separate terminal for meter connection. Block, cable openings and sealable wing nuts on cover discourage tampering.

Allis-Chalmers Mfg. Co., Milwaukee, Wis.



50,000-KVA. INDOOR OIL CIRCUIT BREAKER

INDOOR oil circuit breaker, Type DX-20, has high-speed, inclosed-mechanism, frame construction with deep overhanging flange, all poles in one tank, Bakelin bushings, oil and gas separator, heavy arcing contacts of large thermal absorption capacity. Furnished for 600 amp. at 15 kv., 1,200 amp. at 7.5 kv., and 2,000 amp. at 5 kv. Interrupting capacity, 50,000 kva. Manually-, solenoid- or motor-operated.

Condit Electric Mfg. Corp., Boston, Mass.

WELDING ELECTRODE FOR BRONZE, BRASS AND COPPER

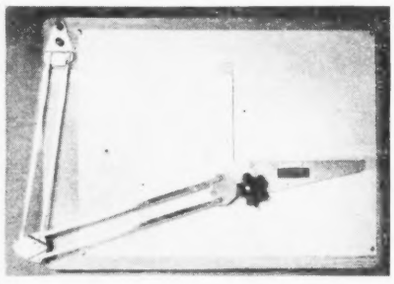
"AERISWELD" phosphor-bronze arc-welding electrode is shielded arc electrode for use with metallic arcs. As coating burns it produces gas which shields molten metal from effects of atmosphere and assists flow of molten metal in arc. Uses positive welding current on electrodes. Made in $\frac{5}{32}$-in. and $\frac{3}{16}$-in., 14-in. lengths, packed in standard containers of 5 lb. net.

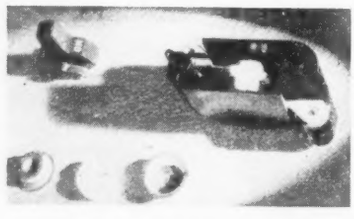
Lincoln Electric Co., Cleveland, Ohio.

DRAFTING MACHINE

"WRIGRAPH" Model E-272 streamlined drafting machine mounted on 22x30-in. cleated, white pine board. Hand-assembled parallel mechanism has all-steel nickel-plated parts on solid phosphor-bronze bearings. Equipped with vernier indicating protractor reading to degrees. Check plate holds drawing attachment in alignment. Graduated L-square blade made of pyroxylin and riveted to lightweight aluminum stiffener with satin finish to eliminate glare. Special baseplate for fastening to wood without screws or clamps.

L. G. Wright, Inc., 5713-37 Euclid Ave., Cleveland, Ohio.





SMALL MERCURY SWITCH

COMPACT switch consists of two shallow chrome-steel cups about $\frac{3}{4}$ in. in diameter, sealed together with strip of lead glass. Separating cups is disk of ceramic material with small hole near edge. Compartment is evacuated after fabrication and contains about four grams of mercury, filling one-quarter of space. After insertion of mercury, compartment is filled with hydrogen at about atmospheric pressure and sealed off by welding. In "off" position hole in ceramic disk is above line of inclosed mercury. When rotated 20 deg. switch assumes position where mercury can flow through hole, thus establishing contacts between cups. Hydrogen used as cooling agent and to quench arc. Tiny plate of steel with 0.2 mil of platinum on surface, is welded to inside of each steel cup.

General Electric Co., Schenectady, N. Y.

JOINT COMPOUND

"COPALIT" packing and insulating compound in liquid and cake form is said to be unaffected by benzine, benzol, mineral oil, dilute acids, high temperatures and pressures, and to possess high electric insulation properties. For use on compressors, cylinder heads, fittings, flanges, housings, motors, dynamos, boilers, tanks, ventilators, etc. Satisfactory as sealing compound for machines using kinetic refrigerants, such as Freon, F-11, F-114, etc. Liquid used for highly machined surfaces where it is possible to apply one layer over another, while paste is for rough surfaces or unfinished parts. "Rustnil" (diluted Copalit) for painting or spraying metal surfaces to prevent rust and resist corrosive liquids or gases. May be painted over exterior or interior paint. Shipped in 1- and 5-gal. containers. No. 1 for brushing and No. 2 for spraying. Bulletin.

National Boiler Improvement Co., 4100 Georgia Ave., Washington, D. C.

SHIM-STOCK DISPENSING UNIT

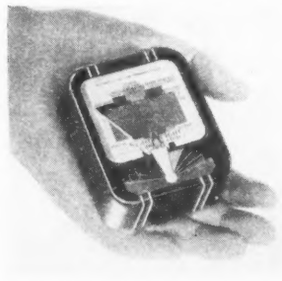
RACK for shim stock, keeps all sizes of 2 x 9 laminated brass and thin shim stock. Amount of stock required pulled through slots in cartons and cut off. Free with purchase of special assortment of shim stock.

Laminated Shim Co., New York, N. Y.

GLASS FILTERS

GLASS air filters for internal-combustion engines, air compressors, warm-air furnaces and ventilating units consist of series of bonded mats and flexible glass fibres confined on intake and discharge faces by expanded metal grilles and inclosed by fibre-board frame. Mass of glass fibres coated with odorless, fireproof, non-evaporating and non-corrosive chemical, physically catch and hold all manner of dust particles. Series of fibrous pads in each filter graduated in fibre diameter and density from coarse (broom-straw size) to fine (human hair) from intake to discharge side. Removed 98% of pollen from air in tests in heating and ventilating systems. Equipped with backfire relief valves. Will gather four times its own weight of 2 lb.

Industrial Market Division, Owens-Illinois Glass Co., Toledo.



ILLUMINATION METER

VEST-POCKET photo-electric illumination meter reads up to 250 foot-candles. Scale is divided in five "seeing task" zones set off by colored divisions. Light-sensitive cell within scale opening directly on scale plate. Measures $2\frac{3}{8}$x$2\frac{3}{4}$ in., has rounded corners.

Weston Electrical Instrument Corp., Newark, N. J.

POWER LINES

Power Conference Program

Program as issued by the Midwest Power Engineering Conference to be held in Chicago, Ill., April 20-23 includes:

Power Economics

Chairman—A. A. Potter, Pres. American Engineering Council.
Trends in Research, by C. F. Hirshfeld, Detroit, Mich.
Interchange of Power and Steam between Industries and Public Utilities, by Wm. A. Hanley, Eli Lilly & Co.
Trends in Power Plant Layout, by Wm. Benson Mayo.

Power Plant Buildings and Dams

Chairman—Daniel W. Mead, Pres. A.S.C.E.
Earthquakes as Affecting the Design of Housing for Power Plants, by P. E. Stevens, Byllesby Engrg. & Management Corp.
Fort Peck Dam, by Claude H. Chorpening, Corps of Engrs., U. S. Army.

Electrical Problems

Two papers will be presented,, one by a representative of General Electric Co., and one by an engineer of the Westinghouse Electric & Mfg. Co.

Diesel and Internal Combustion Engine Power

Chairman—A. C. Kirkwood, Burns & McDonnell Co.
Heavy-Duty Portable Diesel Engines for Construction and Contracting, by G. E. Spain, Caterpillar Tractor Co.
Large Diesel Engine Mechanical Developments, by Max Rotter, Busch-Sulzer Bros. Diesel Engine Co.
Fuels for Diesels, by E. W. Roby, Fairbanks Morse & Co.

Refrigeration

Chairman—L. S. Morse, Pres. A. S. R. E.
Air Conditioning Application, by Zieber & Nicoll, York Ice Mach. Corp.
Refrigerants, by Harry D. Edwards, Carbide & Carbon Chem. Corp.
Fuels, Classification of Coals by Use Value.
Use Value of Coal for Steam Generation, by John Nash.
Some Characteristics of Midwest Coals, by H. L. Olin.
Simplification of Coal Sizing, by J. Harrington.

Power Piping and Welding

Chairman—E. P. Rich, Neiler, Rich & Co.
Valves, by H. H. MacMillen, Milwaukee Elec. Ry. & Lt. Co.
Power Plant Piping, by J. R. Tanner, Pittsburgh Valve, Foundry & Construction Co.
Welding of Alloy Steels and Pipe, by J. R. Dawson, Union Carb. Research Laboratories.

Engineering Economics in the National Power Picture

Chairman—F. F. Fowle, Pres. Western Soc. of Engineers.
Names of three speakers will be announced later.

Power Plant Technics

Chairman—A. D. Bailey, Comm. Edison Co.
Trend of Large High-pressure, High-temperature, Boiler Design, by F. H. Rosencrants, Combustion Engineering Co.
Water Conditioning for High-pressure Steam Generation, Hall Laboratories.
Turbine Operation and Applications.

Fuels and Furnaces

Chairman—E. H. Tenney.
Value of Proper Furnace Equipment to Power Plant Economy, by M. K. Drewry, Milwaukee Elec. Ry. & Lt. Co.
What Modern Fuel-burning Equipment Means to the Industrial Plant, by John C. Kuhns, Staley Mfg. Co.

Power Transmission to Machinery

Chairman—G. C. Miller, Pres. Dodge Mfg. Co.
Modern Group Drives, by W. R. Clendenning, Engrg. Power-Trans. Council.
Load Acceleration and Overload Release, by W. Stanier, E. I. Dupont de Nemours, Inc.
Direct Motor Drives for Machinery Application, by F. E. Butterfield, Commonwealth Edison Co.

Fuel Economy & Controls

Chairman—Paul Doty.
Coordinating the Operation of Boiler Auxiliaries, by A. F. Spitzglass and G. K. O'Connor, Republic Flow Meter Co.
Superimposing of High Pressures on Existing Plants, by Frank Clark, Stone & Webster Engrg. Co.
Modernizing Old Plants, by a speaker from the F. H. A.

Expansion at Miller's Ford

Dayton (Ohio) Power & Light Co. will install a 34,000-hp., 1,400-lb. pressure turbine-generator in its Miller's Ford station. Equipment will include 2 Babcock & Wilcox, 375,000-lb. per hr., 900-deg. boilers; General Electric turbine exhausting into the present header at 235 lb. and 575 deg. F.; 3-phase, 60-cycle, 12,000-volt, 25,000-kw., hydrogen-cooled, G.E. generator, ball-mill pulverizers, electrically-driven, 113,000-cu.ft., 12-in. static pressure, forced-draft fans, 200,000-cu.ft., 12-in. static pressure, induced-draft fans, motors driven by variable-speed drives through hydraulic couplings. Boiler feed consists of two 1,200-lb. pressure, 900-deg. and one 230-lb., 575-deg. turbines driving pumps designed for 1,500 lb. pressure. The station will also contain Cottrell precipitators and a 150-ton skip hoist.

Power Equipment for Union Bag & Paper Mill

Union Bag & Paper Corp. has ordered from General Electric Co. a 6,000 kw., 0.80 power factor, 3-phase, 60-cycle, 2,400-volt, 3,600 r.p.m. steam turbine-generator for its paper mill being constructed at Savannah, Ga., to make paper from slash pine. This unit is a double automatic extraction, condensing type with a direct-connected exciter and the necessary accessories. Steam conditions at the throttle will be 400 lb., 750 deg. F. total temperature. Steam will be extracted automatically from the turbine at 125 lb. and 30 lb. gage, with a 2-in. Hg. absolute pressure in the condenser. Other equipment in the order includes high-voltage and low-voltage feeders, distribution switchgear panels, 750-kva. and 37.5-kva. distribution transformers, various motors and control equipment including sectional-paper-machine drive, ten 350-hp. Jordan motors and approximately 5,000-hp. of general-purpose motors and control.

The Babcock & Wilcox Company has been given a contract for three Stirling boilers, each having 4,785 sq.ft. of heating surface, and designed for 450 lb. pressure and 750 deg. total temperature, with a maximum steaming capacity of 150,000 lb. per hr. Included with the boilers are superheaters, air heaters, 3 wood-burning furnaces and 9 steam-mechanical atomizing oil burners, three per boiler. There are also being installed three 67.5-ton black-liquor recovery units for 450-lb. pressure, consisting of superheaters, water-cooled furnaces, return-bend economizers, air heaters and one mechanical-atomizing oil burner per unit.

10,000,000-Cu. Ft. Gas Holder for Ford

World's largest welded-steel gas holder, 220 ft. in diameter by 344 ft. high, will be built by Stacey Brothers Gas Construction Co., Cincinnati, Ohio, for Ford's Rouge Plant.

The holder, with a new propane gas-mixing station and a $4,000,000 coke-oven expansion program, will enable the company to make more economical use of gas produced by the coke ovens. The 10,000,000-cu.ft. holder will serve as a temporary storage center, storing gas during periods of light plant consumption and releasing it during heavier plant activity. Propane mixing station will serve as a standby and meet peak loads by mixing propane (2,500 B.t.u. per cu.ft.) and blast furnace gas (100 B.t.u. per cu.ft.) in 1-5 ratio.

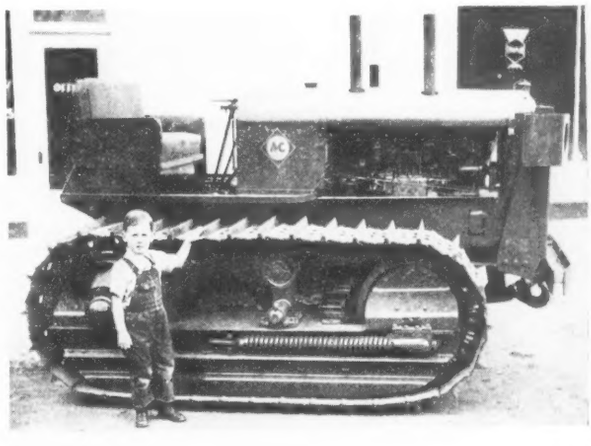
The gas holder and a new 20,000,000-cu.ft. compressor will be built near the south end of the open hearth furnace dept.

Rochester Gas & Electric To Add Second New Unit

The Rochester Gas & Electric Corp. will start work shortly on a new 7,500 kw. high-pressure "top" for its No. 3 plant. The boiler will have a maximum continuous rating of 250,000 lb. per hr. at 650 lb. and 750 deg. the same as the present unit, described in this number. The first unit is the equivalent to a 650-lb. 750-deg. "top" on a 15,000 kw. 200 lb. 530-deg. machine. The second unit will be the equivalent of a "top" on two 10,000-kw. machines.

PLAY TOY

Warren Chandler, 3, proves that diesels are so easy to start, "a child can do it" by starting and stopping the 49-hp. Allis-Chalmers oil tractor 40 times. For starting, this tractor requires only 2 or 3 shots of gasoline with a primer. Ignition is accomplished with a magneto and spark plugs.



POWER and the FLOOD

(Continued from page 211)

mitted supplying 25,000 kw. to Duquesne Light Co. Up to the time Duquesne plants went out, this system supplied between 10,000 and 15,000 kw. to West Penn Power.

Water at this station stood 2 ft. in the turbine-room floor. This submerged a small portion of the stator, but it is not yet known whether the windings will have to be dried out. Depending on this, this plant was expected to be back in operation with one unit Monday or Tuesday, March 23 or 24. The condenser pit was entirely submerged, but some motors were removed and kept dry, which, together with new motors, will permit starting one unit. On March 21 the plant was completely unwatered.

Westinghouse Helps Out

Because of special production facilities and trained personnel for renovating flooded equipment in minimum time, the City Engineer and local utility extended Westinghouse every cooperation to speed repair work in the crisis. The electric company furnished 500 kw. 12 hr. after the general power failure while Pittsburgh remained in darkness, and the city placed the plant on the same schedule as hospitals for water to supply the steam-heated drying ovens. Hours after the flood reached its crest of 46 ft. about midnight Wednesday, March 18, Westinghouse's Superintendent S. C. Hoey and Service Manager Elmer Simpson constructed 9 drying ovens by candle light, formulated a repair schedule for large utilities and industrial plants to prevent swamping facilities, set 450 trained employees working in two 12-hr. shifts.

Over the weekend of March 21, about 1,500 units arrived for repair, and at one time eleven trucks were lined up to unload. Motors, circuit breaker coils, regulators, control boards and similar devices are still pouring in (Mar. 25) at about 500 units per day, the incoming load being controlled to some extent by scheduled allotments. Working day and night the plant is turning out 200 finished and tested units every 24 hr. The rapid delivery is the result of 17 special vacuum drying ovens, some electrically heated and others by steam in case of power failure such as occurred in flooded Pittsburgh. The vacuum ovens maintaining 95-110 deg. C. temperature, dry out 25 stators and 25 rotors in about 6 hr. as compared to 16 hr. for conventional repair-shop ovens. New coils for motors are wound on the spot, as are solenoid closing coils for circuit breakers and coils for regulating devices.

Motors form the bulk of the damaged equipment and range in size from ¼ hp. for a regulator to 400 hp. at 275 r.p.m. for boiler-feed pumps at local generating stations. Where impractical to bring the equipment to the plant, experts are sent to do the job on location. For example, 100 steam specialists were rushed by trucks from Westinghouse's Philadelphia Plant to aid in servicing generating units.

With still thousands of Pittsburgh motors yet to be cared for, including those still under water, the special facilities of the Westinghouse Renewal Parts Plant are already being demanded by Eastern flood districts. Manpower for continued high-speed production is adequate, provided repair materials, such as insulation, micarta, tape, varnish are not exhausted before promised deliveries arrive.

New England

New England rivers were likewise on a rampage, the crest of the flood following that in Pittsburgh by a day or two at Hartford. Several small power dams were broken, but without interruption to power service until Dutch Point and South Meadow Stations at Hartford were submerged, throwing the town into darkness for 48 hours until a tie-in could be effected.

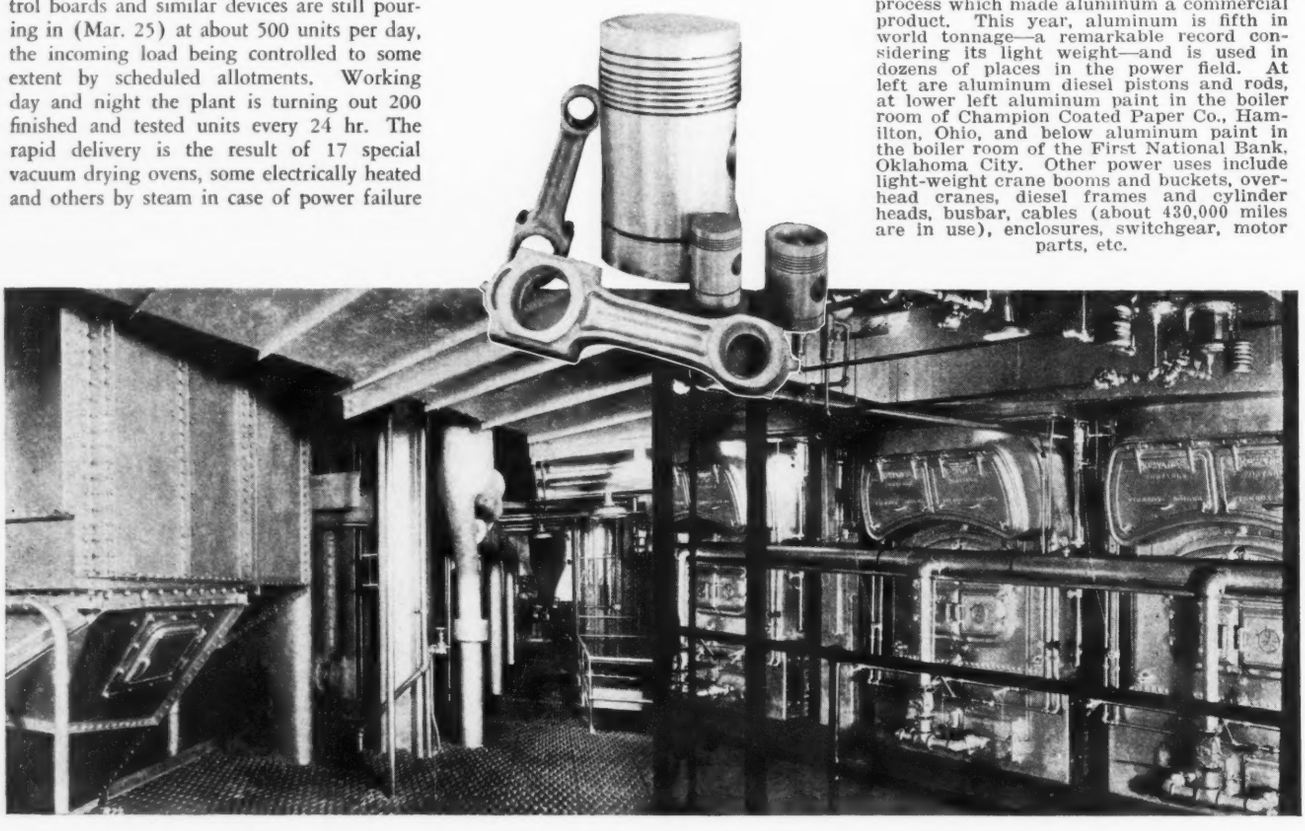
The trouble in New England began as early as Mar. 12, when heavy rainfall released the ice. One operator lost his life at Greggs Falls plant, near Manchester, N. H., trying to remove flashboards, and an attendant at an industrial power plant near Salmon Falls on the Merrimac River was drowned doing similar work. Four plants of Central Maine Power Co. were flooded in the Kennebec and Messalonskee valleys, and the private railroad serving Wyman Station at Bingham was badly damaged by ice.

Webster steam plant of New England Power Assn. had a flooded boiler room, and high water threatened Millbury switchyard and other stations on the Connecticut and Deerfield Rivers to a lesser degree, except for Scotland Dam plant of Conn. Light & Power Co. on Shetucket River above Norwich, which was demolished by ice about 11 P. M., Mar. 12. The plant had been abandoned at 9 P. M., service being maintained by interconnected lines. The plant contained three 400-kw. horizontal water-wheel, 2300-volt generator units under 27-ft. head, installed in 1908. When the river rose above the dam crest, ice was swept over the brink and through the station building, carrying everything before it. The plant was valued at something over $100,000, but may not be rebuilt immediately, in view of the pending extension of the nearby Montville steam plant by a 25,000-kw. unit.

Many industrial power plants in New England took over local lighting and power loads when normal facilities were put out by the flood. For example, Corning Glass Works carried the Corning, N. Y., load for 24 hr., Ingersoll Rand's plant at Painted Post, N. Y., carried the load there, Nashua Mfg. Co., Nashua, N. H., took it there, and American Optical Co. and Ames Worsted in Southbridge, Mass., divided between them the load from four or five surrounding towns.

ALUMINUM IS 50 AND FIFTH

Just 50 years ago, 22-year-old Charles Martin Hall discovered the electrolytic process which made aluminum a commercial product. This year, aluminum is fifth in world tonnage—a remarkable record considering its light weight—and is used in dozens of places in the power field. At left are aluminum diesel pistons and rods, at lower left aluminum paint in the boiler room of Champion Coated Paper Co., Hamilton, Ohio, and below aluminum paint in the boiler room of the First National Bank, Oklahoma City. Other power uses include light-weight crane booms and buckets, overhead cranes, diesel frames and cylinder heads, busbar, cables (about 430,000 miles are in use), enclosures, switchgear, motor parts, etc.



Cleaning mud and silt from the thrust bearing on a condensate pump in a flooded Pittsburgh central station. Westinghouse photo.

NEWS NOTES

TOTAL capacity of hydro-turbines in the U. S. Jan. 1, 1936, according to the annual report of the Department of the Interior through the Geological Survey, was 16,079,407 hp., an increase of only 4,100 hp. during the year.

N.A.P.E., Greater New York Assn. No. 1, has been given the awarding of a series of silver, bronze and aluminum medals to its members for the best performance in connection with practical running of steam engines by Robert Grimshaw of Leonia, first president of the James Watt Assn. of Stationary Engineers. Mr. Grimshaw holds the record made in the eighties for rapid indication at a meeting of the Franklin Institute, where he took a card from a Roberts reciprocating engine at 1,120 r.p.m. making the hook attachment by hand for each card.

DAVID L. FISKE, executive secretary of the American Society of Refrigerating Engineers will represent the society at the 7th international congress of refrigeration to be held the week of June 16, 1936, at the Hague, Holland. Mr. Fiske plans to make a tour touching several countries besides Holland at the same time. Willis H. Carrier, chairman of the board of the Carrier Engineering Corp., now on a trip around the world, will also attend the congress.

ST. LOUIS WELDING SOCIETY marked its fifth anniversary recently by publishing a history of the society by Lockwood Hill, Exec. Secy. The organization which was formed in 1931 with only six "Firm" members now has 73 and is "striving to perfect and advance the art of welding."

A.S.T.M. Committee D-19 on Water for Industrial Uses released for publication, as information only, methods of analysis of four ions, carbonate, hydroxide, phosphate and sulphate. These methods were originally developed by the subcommittee on Water Analysis of the Joint Research Committee on Boiler Feedwater Studies.

REFRIGERATING MACHINERY ASSN. will meet May 14, 15 and 16 at Hot Springs, Va., to discuss the standardization program which the Association has undertaken. Air Conditioning Manufacturers Assn. will hold its annual meeting at Hot Springs May 16.

OIL BURNER INSTITUTE, INC., 30 Rockefeller Plaza, New York, N. Y., is sponsoring the twelfth National Oil Burner Show to be held at Detroit, Mich., April 14-18. G. Harvey Porter is Managing Director.

SECOND CONFERENCE ON SOLID FUELS AND DOMESTIC STOKERS at the University of Wisconsin, April 21 to 23, will feature discussion on the production and sale of solid fuels, domestic stokers and related equipment.

OBITUARIES

WILLIAM M. BRAGGER, 72, steam plant engineer for Boston Hospital, and later for Boston Elevated Railway, died Feb. 2.

RAYMOND DILL, 55, treasurer of Allis-Chalmers Mfg. Co. since 1923, died March 17. After graduating from Ohio State Univ., Mr. Dill joined Westinghouse Electric & Mfg. Co. In 1905 he went to the Bullock, Cinn., Works of Allis Chalmers.

FRANCIS R. HEALEY, 57, Superintendent for Union Gas & Electrical Co., Cincinnati, Ohio, for 30 years, died March 16.

DAWSON H. SKEEN, 49, president of D. H. Skeen & Co., Chicago, Ill., died Feb. 23. After graduating from the U. S. Naval Academy in 1910, Mr. Skeen served in the Navy Steam Engineering Bureau at Washington during the World War and later became assistant to the president of Edward Valve & Mfg. Co. Before starting the firm of D. H. Skeen & Co. in 1922, he was superintendent of the Edward works in East Chicago, Ind.

PERSONALS

Francis Hodgkinson

FRANCIS HODGKINSON, co-worker with Sir Charles Parsons and later right-hand man of George Westinghouse in development of the steam turbine in the U. S., has retired from Westinghouse Electric & Mfg. Co. after 42 years of service. After graduating from the Royal Naval School, Newcross, England, Mr. Hodgkinson became associated with Sir Charles Parsons in the early development of the reaction steam turbine. In 1890 he joined the Chilean Navy and served during the revolution at that time. From 1892 to 1894 he was with the Telephone & Electric Light Co. of Lima, Peru, and in connection with mining properties at Casapalca, Peru. In 1894 he joined C. A. Parsons & Co. as superintendent of the erecting and fitting shops. In 1896 he initiated the design and construction of steam turbines for Westinghouse Machine Co., which had taken over the Parsons Co. He was responsible for steam-turbine construction until 1916 when he was made chief engineer responsible for all steam-power apparatus of Westinghouse Electric & Mfg. Co. Mr. Hodgkinson was awarded the silver medal of the Louisiana Purchase Exposition, in St. Louis in 1904. In 1925 he won the Elliott Cresson Gold Medal from the Franklin Institute of Philadelphia; in 1931 the Willans Gold Medal of the Institution of Mechanical Engineers and the Institution of Electrical Engineers of Great Britain. He was given an honorary degree of Mechanical Engineer from Stevens Institute of Technology in 1934.

ROBERT E. DILLON, superintendent of the generating department of Edison Electric Illuminating Co. of Boston, Mass., recently celebrated the completion of his 25th year of service with that utility. In 1925 Mr. Dillon was made superintendent in charge of all generating plants and substations for the system.

L. D. HOLLAND, formerly sales manager, combustion division, has been made general manager of research dept., for E. F. Houghton & Co., Philadelphia, Pa. A. A. MILLER, formerly head of the Cincinnati, Ohio, office, has been promoted to western sales manager with headquarters in San Francisco, Calif.

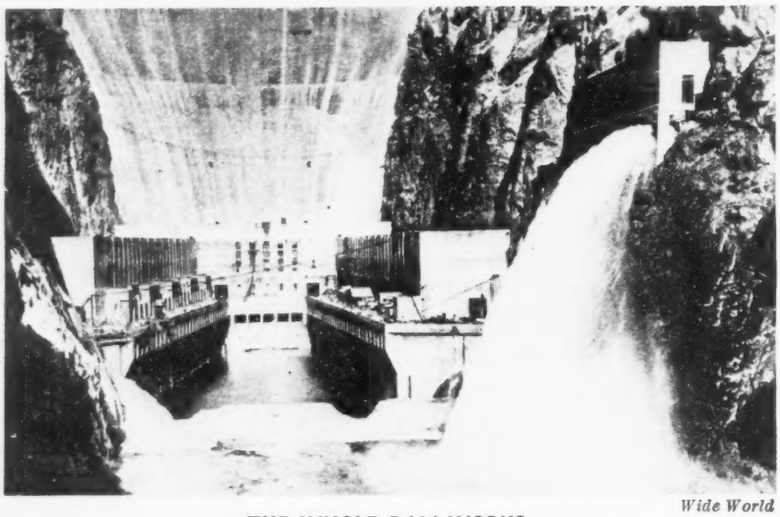
HAROLD K. BARROWS, professor of hydraulic engineering at M.I.T. and former district engineer of water resources for U. S. Geological Survey for New England, was elected president of Boston Society of Civil Engineers, March 11.

GORDON A. STEPHENS was elected vice president and managing director of Affiliated Engineering Corps., Ltd., Montreal, Canada, at the annual meeting of the board of directors, Feb. 22. Other officers re-elected were: W. V. Sauter, chairman of the board; Joseph G. Worker, pres.; and C. L. Cushmore, treas.

JOHN ROLFE will succeed James H. Gregory as sales promotion manager for All-Steel-Equip Co., Aurora, Ill.

J. D. Yoder

J. D. YODER, former vice-president and general manager of Cochrane Corp., has accepted a sales executive position with Permutit Co., 330 West 42nd St., New York, N. Y.



Wide World

THE WHOLE DAM WORKS

Water being diverted through the penstock at Boulder Dam for the first time issues from one of the six canyon wall outlets on the Arizona side. This test run filled the tailrace and provided water for irrigation below the dam. One of the old diversion tunnels which is still passing water will be plugged as soon as the remaining penstocks are completed.

STRAWS

Pointing the way business winds blow

PUTNAM (CONN.) WOOLEN CORP., has contracted E. J. Cross Co., 82 Foster St., Worcester, Mass., for 1-story boiler plant for mill service. Cost close to $30,000, with equipment. Joseph C. Bogue, 25 Huntington Ave., Boston, Mass., consulting engineer.

CONSTRUCTION SERVICE, Veterans' Administration, Washington, D. C., receives bids until April 14 for boilers, stokers and auxiliary equipment for power house in institution at Dayton, Ohio.

VINELAND, N. J., has ordered one 7-retort, hydraulic-type, Taylor stoker and 450-lb. pressure, 8,000-sq.ft. Stirling boilers. Stokers regulated by Hele-Shaw hydraulic drives.

WALTER E. FERNALD SCHOOL through Commonwealth of Massachusetts has ordered a Taylor stoker for 3,000-sq.ft. Keeler boiler.

NORWALK (CONN.) GENERAL HOSPITAL plans addition, 22x38 ft., to boiler plant on Stevens St., including two new boiler units and accessories. Robert S. Schultz, Jr., 36 Euclid Ave., Maplewood, N. J., engineer.

PHILADELPHIA (PA.) ELECTRIC CO. will modernize its Willow St. heating station with two Taylor stokers to raise boiler capacity to 130,000 lb. each.

South

MIAMI, FLA., plans motor-driven pumps and auxiliary equipment for increased water supply. Cost about $50,000. Claude A. Renshaw, city manager, in charge.

ARANSAS COMPRESS CO., Corpus Christi, Tex., plans 1-story boiler house in connection with new cotton compress plant on 10-acre tract at Brownsville, Tex. Cost $200,000. J. K. Cain, president, in charge.

T.V.A. is considering construction of a dam across the Tennessee River at Gilbertsville, Ky.

MUTUAL CHEMICAL CO., Baltimore, Md. has contracted American Engineering Co., Philadelphia, Pa., for one 5-retort Taylor stoker for 6,200-sq.ft. Vogt boiler with A-E-Co water-cooled bridge walls.

NATIONAL WHOLESALE LIQUOR CO., 410 East Pratt St., Baltimore, Md., plans steam plant at proposed distilling plant on 16-acre tract on Philadelphia Road, near Baltimore.

NORFOLK, VA., has Federal loan and grant of $492,000 for municipal power plant at South Norfolk.

BIRMINGHAM, ALA., has engaged Sanborn & Bogert, 30 Church St., New York, N. Y., to supervise installation of industrial water supply system. $6,000,000 secured through Federal aid. J. D. Webb, city engineer.

HIDALGO GAS CO., Houston, Tex., operated by Showers & Moncrief, Inc., Houston, plans welded-steel pipe line for natural gas transmission to San Juan Mission, Tex. Cost close to $300,000. Frank McCarthy, manager.

DELTA, COLO., has $197,000 Federal loan and grant for municipal power plant. Diesels are being considered. Wood & Weber, Wilda Bldg., Denver Colo., engineers.

GEORGIA POWER CO., Atlanta, Ga., plans improvements in artificial gas plant at Bay Ave. and Dillingham St., Columbus, Ga. Station will be used for auxiliary and emergency service for distribution of natural gas.

BONDS MILL DISTILLING CO., McBrayer Station, near Lawrenceburg, Ky., plans water-power plant for distillery on Salt River. Boiler house and engine plant for emergency. R. E. Johnson, president.

BELFALLS LIGHT & POWER CO. proposes diesel generating plant at Temple, Tex., with funds provided by REA.

CLARKS HILL, S. C., flood control and hydro-electric project should be started immediately, according to the recommendation of a special board to President Roosevelt.

VIRGINIA ELECTRIC POWER CO., Richmond, Va., plans extensions in power house at artificial gas plant at Norfolk, Va., including boilers. $135,000 being arranged.

SAN BENITO-PORT ISABEL NAVIGATION DISTRICT, San Benito, Tex., plans precooling and refrigerating plant in fruit- and vegetable-handling building, 100x200 ft. Unit will cost about $200,000, with equipment.

T.V.A. has awarded $43,775 contract to Westinghouse for auxiliary switchboards for Wheeler Dam.

Mid-West

POSTUM CO., INC., Battle Creek, Mich., will install a Babcock & Wilcox, Type F. pulverized-coal-fired, integral-furnace-boiler and a 3,570-kva. turbine-generator unit. Unit will generate maximum byproduct power obtainable from process and heating steam normally carried on high-pressure boiler with 100,000-lb.-per-hr. steaming capacity. Supplementary power will be purchased from Consumers Power Co. Present low-pressure steam equipment will serve as standby. Steam conditions at superheater outlet will be 650 lb. gage and 720 deg. F. Stone & Webster Engrg. Corp., supervising.

PANHANDLE EASTERN PIPE LINE CO., 101 West Eleventh St., Kansas City, Mo., is awarding contracts for welded-steel pipeline for natural-gas transmission to Detroit, Mich., from Dana, Ind. Contract for 235 miles of 22-in., seamless-steel pipe awarded to National Tube Co., Pittsburgh, Pa., for $3,500,000. Contract for twelve 1,300-hp., and two 1,000-hp., twin-tandem gas-driven gas compressors with accessories, has been placed with Cooper-Bessemer Corp., Mount Vernon, Ohio. Cost $16,000,000.

MISSOURI STATE BLDG. COMMISSION, State Capitol Bldg., Jefferson City, Mo., has approved plans for extensions in steam plant at institution at Marshall, Mo., including boiler units and auxiliary equipment. Cost about $225,000. J. H. Porter & Co., and George E. Wells, Inc., Security Bldg., St. Louis, Mo., consulting engineers; Charles A. Haskins, Finance Bldg., Kansas City, Mo., supervising.

SOUTH RIVER DRAINAGE DISTRICT, Marion County, Hannibal, Mo., John L. Plowman in charge, will receive bids until April 20 for drainage pumping station for system near Hannibal, comprising three diesel-driven pumping units with accessory equipment.

IOLA, KAN., will call for bids for municipal power plant and distribution system, including substation to include steam turbo-generator and accessories. Cost $225,000. Paulette & Wilson Engineering Co., National Reserve Bldg., Topeka, Kan., engineer.

PARAGOULD, ARK., will soon begin construction of municipal light and power plant. Cost about $190,000, with equipment. W. A. Fuller & Co., 2916 Shenandoah Ave., St. Louis, Mo., consulting engineers.

SOUTHWEST UTILITY ICE CO., 520 A St., Blackwell, Okla., plans remodeling ice and cold storage plant. Cost $35,000.

OMAHA FLOUR MILLS CO., W.O.W. Bldg., Omaha, Neb., plans diesel plant for flour mill and grain elevator at Denver, Colo. Cost about $300,000. Horner & Wyatt, Board of Trade Bldg., Kansas City, Mo., engineers.

BECKETT PAPER CO., Hamilton, Ohio, soon takes bids on revised plans for power house for mill service, to include high-pressure boilers, stokers, pumping machinery, etc. Cost $200,000. Fosdick & Hilmer, Union Trust Bldg., Cincinnati, consulting engineers.

SOUTH CHARLESTON, OHIO, is considering municipal light and power plant and will estimate cost soon.

CINCINNATI, OHIO, has permit for electric pumping plant in Western Hills district for municipal water supply system. Cost over $125,000 with equipment. Joseph G. Steinkamp, Mercantile Library Bldg., architect.

DEFIANCE MILK PRODUCTS CO., Defiance, Ohio has ordered a Taylor stoker for a 5,000-sq.ft., 200-lb. pressure, Stirling boiler.

IRON FIREMAN MFG. CO., Cleveland, Ohio, has contracted Austin Co. for two additions to its automatic coal-burner plant. First is steel-framed building 172 ft. wide by 211 ft. long, second is 25x200 ft. "lean-to."

KROGER GROCERY & BAKING CO., 35 East Seventh St., Cincinnati, Ohio, plans extensions in steam plant on Lockbourne Road, Columbus, Ohio, with installation of powdered-fuel units, pumping machinery, boiler equipment, etc. Cost about $85,000. A. M. Kinney, Inc., Carew Tower, Cincinnati, consulting engineer.

CHEVROLET MOTOR CO., Indianapolis, Ind., has contracted for Taylor stokers for two Union 5,000-sq.ft. boilers. 575-lb. pressure boilers are for a new body plant.

MUNICIPAL LIGHT & POWER CO., Huntington, Ind., has acquired about 4½ acres near city limits for steam-electric plant. Plans will be drawn soon. Cost reported over $125,000.

DECATUR, IND., has secured low bid from General Electric Co., Schnectady, N. Y., for turbine unit with accessories for municipal power plant, at $50,440; and for condenser equipment from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., at $19,755. G. E. also tendered low quotation for exciter unit, switchboard panels and auxiliary equipment. Entire project will cost about $110,000. Bevington-Williams, Inc., Indiana Pythian Bldg., Indianapolis, Ind., consulting engineer.

PETERSBURG, IND., plans municipal powerplant to cost about $35,000. Financing through Federal aid.

FISHER BODY CORP., Detroit, Mich., has contracted for 6-retort Taylor stokers for 6,000-sq.ft. Stirling boilers.

INTERNATIONAL HARVESTER CO., 606 S. Michigan Ave., Chicago, Ill., has revised plans for 3-story and basement power plant, 50 x 62 ft., at branch factory on Lagonda Ave., Springfield, Ohio. Cost over $100,000, with equipment. W. H. Kruger, company engineer, in charge.

DARLINGTON, WIS., plans municipal plant and will begin work immediately following call for bids. Will include two diesels, with provision for third unit later. Cost about $200,000. Van Vleet Engrg. Co., Union Trust & Savings Bank Bldg., Dubuque, Iowa, consulting engineer.

CENTRAL WEST PUBLIC SERVICE CO., Sioux City, Iowa, plans ice-manufacturing and refrigerating plant on South Wall St. Cost close to $35,000.

VINTON, IOWA, has contracted Fairbanks, Morse & Co., Chicago, Ill., for 750-hp. diesel-generator unit and auxiliary equipment in municipal plant, for $54,986. Existing steam unit will be removed. Howard R. Green Engrg. Co., 417 First Ave., S.E., Cedar Rapids, Iowa, consulting engineer.

FORD MOTOR CO., Dearborn, Mich., used 658,247,947 kw.-hr. during 1935 in the Detroit area, 145,000,000 kw.-hr. more than that used during 1934. Of the total, 645,866,091 kw.-hr. were generated and used at the Rouge plant; 3,541,000 kw.-hr. were purchased for Rouge, and the remainder was generated and used at other Ford plants.

NEW ULM, MINN., has contracted Power Service Corp., Wesley Temple Bldg., Minneapolis, Minn., for extensions in municipal power plant, at $48,187. New equipment includes superheaters, pumping machinery, switchboard, piping, etc. Ralph D. Thomas, 1200 Second Ave. S., Minneapolis, consulting engineer.

CITY OF ROCHESTER, Minn. has let contracts for water-cooled Taylor stoker for 10,000-sq.ft. 360-lb. pressure, Union boiler.

INDEPENDENT SCHOOL DISTRICT NO. 27, Hibbing, Minn., plans early call for bids for automatic stokers and accessories for schools where boiler plants will be improved.

STATE COMMISSION OF ADMINISTRATION AND FINANCE, State Capitol Bldg., St. Paul, Minn., will begin work soon on steam power plant at institution at Faribault, Minn. Cost about $30,000. Pillsbury Engrg. Co., 1200 Second Ave. S., Minneapolis, Minn., consulting engineer.

IMPERIAL, NEB., will begin work on extensions in municipal plant to cost about $60,000. Portion of equipment to Fairbanks, Morse & Co., Chicago, Ill. Henningson Engrg. Co., Union State Bank Bldg., Omaha, Neb., consulting engineer.

PLANKINTON, N. D., has authorized extensions in municipal power plant, including diesel and auxiliary equipment.

GARDEN CITY, KAN., plans extensions in pumping plant, including 8,000-g.p.m. pumping units and auxiliary equipment.

West Coast

BAKER VALLEY IRRIGATION ASSN., Baker, Ore., is surveying for dam on Powder River for power and irrigation. Three alternate plans are being considered for project, one to include construction of a hydroelectric plant, with transmission lines and substation for series of pumping plants for about 31,000 acres of land. Cost estimated at $3,600,000. T. B. Montgomery is president of organization. U. S. Reclamation Service will be active.

BOWDOIN NATURAL GAS CO., Bowdoin, Mont., acting with British-American Gas Syndicate, Regina, Sask., plans 185-mile welded-steel pipeline from Bowdoin gas field for natural-gas transmission to Regina and Moosejaw, Sask. Cost about $5,500,000.

SALEM, ORE., plans water supply development with source on North Santiam River, near Stayton, Ore., about 18 mi. from city. 36-in. steel pipeline will be constructed to city limits. Includes storage reservoir, pumping station and distributing facilities. Bond issue of $1,150,000 is being arranged. Stevens & Koon, Spalding Bldg., Portland, Ore., consulting engineers.

PUBLIC UTILITIES COMMISSION, San Francisco, Calif., plans electric pumping plant at Irvington for municipal water system. Cost close to $50,000. Also plans two steel pipelines for water service from Crystal Springs dam to Burlingame, cost about $580,000; and discharge line from Sunset reservoir, cost $250,000. To ask bids soon. N. A. Eckart, 425 Mason St., engineer.

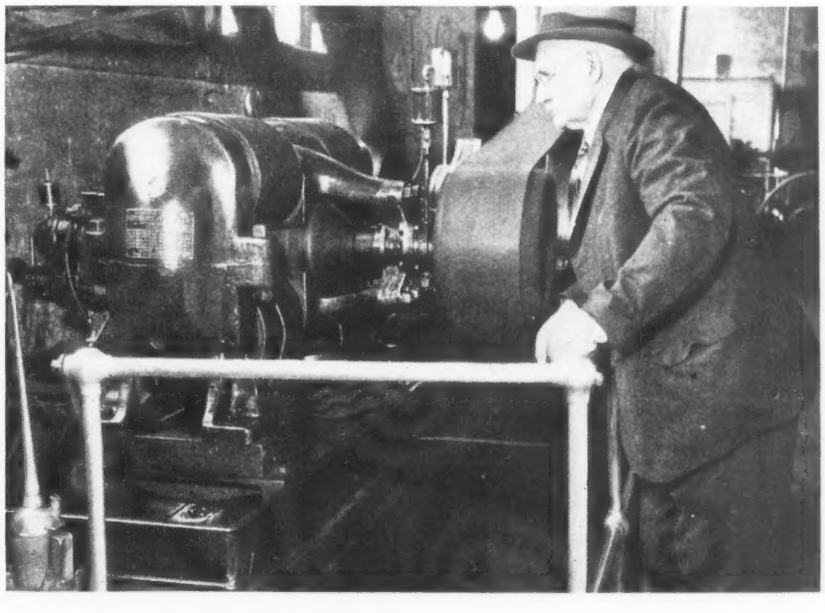
LASSEN LUMBER & BOX CO., Susanville, Calif., has approved plans for extensions in mill power plant to cost over $45,000. Hunt, Mirk & Co., 141 Second St., San Francisco, Calif., consulting engineers.

HYLAND STANFORD CO., INC., 658 Mesquito St., Los Angeles, Calif., plans 1-story steam plant, 67 x 79 ft., at industrial plant. Cost about $28,000, with boilers and auxiliary equipment. Nigg Engrg. Corp., Covina, Calif., engineer.

NAPA, CALIF., has called special election May 4 to approve municipal light and power project. Propose to purchase existing distribution system.

OLD, BUT NOT FEEBLE

George D. Lyon, 70 year old manager and chief engineer for the Standard Ice Co., gazes with admiration at his Westinghouse generator which has given 42 years of continuous service. The unit has been producing current for about 200 lamps and a number of small ventilating fans in the ice plant.



EMERGENCY . . .

I walk into POWER'S editorial office to find it humming like the movie picturization of a newspaper office. From Swain in Europe come cables on foreign power developments. Purdy is just back from the Pittsburgh flood area and the power failure there. Annett is leaving for New England on the same errand. The rest of the staff are feverishly checking copy, rushing it to the printer so that both the planned Air Conditioning Section and unplanned material on the flood can be published.

Bound volumes of POWER for several years back are strewn around, each open to a story on what to do after a flood, for the editors are assembling all the data they have available on how to get a plant back into service, rushing it to their 5,000 readers in the stricken districts. They tell me that any other power engineers who want the data, either for immediate use or in readiness for possible future need, can get it simply by writing in to them for it.

The job now is to get plants running again. But after the engineer gets out from under the emergency work, the flood gives him a good chance to pause and reconsider his plant, a good peg upon which to request again the new equipment he needs. Above all else, don't spend too much money fixing up equipment that is basically obsolete—you'll find it far better and cheaper to pitch it out and begin now on a practical modernization program.

Without flood or catastrophe, the power engineer knows the vital need for his product in the community. Trouble at Hell Gate brought New Yorkers up short and made them realize what life without power may mean. Now catastrophe through the East has spread that knowledge wider. It is safe to say that almost everyone east of the Mississippi knows now that his life today depends primarily upon power.

One thing disaster teaches us is how much we depend upon each other—and how much we depend upon the power engineer, and the power engineer in turn upon the manufacturer. From the lowly waste now being used to swab the slime from flooded units to the most intricate instruments, we power engineers must depend upon the manufacturer for immediate delivery of vitally necessary parts when trouble strikes. Perhaps this all will make us understand his problem better, as the public will understand ours. It should bring a more thorough understanding of the problems of public utilities, power engineering in general, and their relation to the highly involved social and economic life of today.

Another thing I learned from this month's visit to the editors—the copy of POWER in which you read this will include a 20-page section of data on air conditioning, that bugaboo of so many of us during the last few years. John Cogan, assistant manager of R. H. Macy & Co., world's largest department store, explained that probably most engineers are in his position—they know exactly what power facilities they have available, and the condition of each element, but they don't know much about air conditioning. His advice is to learn enough about the subject so you understand what's being said, then hire an air-conditioning specialist to do the work. Work with him (he'll be glad of your knowledge of the plant), with the contractor and the equipment builder during installation, and by the time it's in, you'll know enough about it to operate it.

The material in this section, from what I've seen of it, should help the engineer to overcome his gunshyness on air conditioning. It does one thing I haven't seen before—it breaks air conditioning down into a bunch of familiar elements—heating, cooling, cleaning, moistening, drying, mixing and so on, all of them familiar, then shows how they're combined into that unfamiliar thing, air conditioning. And the bugaboo, like the colored man's ghost, turns out to be nothing but a white horse in the moonlight.

George Edwards

GEORGE EDWARDS,
Engineer.